Developing a Protocol for an Environmentally Preferable Purchasing Plus (Epp+) Program at Nasa Glenn Research Center

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DEVELOPING A PROTOCOL FOR AN ENVIRONMENTALLY PREFERABLE PURCHASING PLUS (EPP+) PROGRAM AT NASA GLENN RESEARCH CENTER

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To my beloved parents, Mr. Prinya and Mrs. Amporn Kongtawelert who supported and encouraged me throughout my life.
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DEVELOPING A PROTOCOL FOR AN ENVIRONMENTALLY PREFERABLE PURCHASING PLUS (EPP+) PROGRAM AT NASA GLENN RESEARCH CENTER

AMARIN KONGTAWELERT

ABSTRACT

EPP+ or Environmentally Preferable Purchasing Plus is an Environmentally Preferable Purchasing program with incorporated a unique Life Cycle Assessment (LCA) scoring system which implemented at NASA, Glenn Research Center.

A protocol has been developed to aid in selecting among products based on principles of Environmentally Preferable Purchasing (EPP) and Life Cycle Assessment (LCA). The protocol has been developed for use at NASA Glenn Research Center (GRC) but is intended to benefit anyone wishing to make sustainable purchasing decisions. The protocol was designed as a web-based application which evaluates the life cycle factors, affirmative procurements, price, and performance of products that impact or benefit the environment and human health.

There were 2 parts in the development of the EPP+ protocol. The first part was the development of product scoring system guidelines. All products are to be scored using a numerical rating system for each value. A numeric-based rating system has been developed by applying the priorities of the environmental protection and management policies for the purchase of products for GRC. These ratings are then multiplied by a weighting factor which is a numeric value between 0 and 1.0. During the product
Second part was the development of the EPP+ computer software or protocol (ASP.net format). This protocol produces a score for a product based on a series of ratings and weighting factors given by the expert user. Following the same sequence of operation, various products can be scored and compared, and a list can be prepared for the products that qualify as environmentally preferable products. The lists of products are intended to be offered to contractors and other GRC personnel for their applications. Since the product score is a numeric value, it is easy for a non-expert person to understand and compare with some other products, rather than needing to study the details related to rating and evaluation.

The protocol designed and developed under this study will aid administrators in evaluating and scoring environmentally preferable products. It will also help users to select products rated by evaluators, thereby providing a tool to make more sustainable products decisions.
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CHAPTER I
INTRODUCTION

1.1 Background

The United States of America is a country with a population that represents only 5% of the world’s occupants, but it consumes almost 25% of the world’s resources. If this trend continues on an ongoing basis (that is, if the resources are consumed much faster than they are being replaced), a serious environmental resource crisis will develop. The United States federal government is one of the world’s largest consumers (U.S. EPA, 2006). Indeed, it is the single largest consumer of goods and services within the United States, with total spending estimated at $350 billion for goods and services each year (U.S. EPA, 2008).

In 1998, in order to improve the Federal Government’s use of recycled products and environmentally preferable products and services, President Bill Clinton signed an Executive Order (E.O.) 13101, “Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition”.
The term, “environmentally preferable” is defined in Section 201 of E.O. 13101 to mean products or services that “have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. This comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product or service.”

Therefore, the Environmentally Preferable Purchasing (EPP) program is a nationwide program established by the U.S. Environmental Protection Agency (EPA) in response to E.O. 13101 that encourages and assists federal agencies in purchasing the environmentally preferable products and services.

In 2000, President Bill Clinton signed an Executive Order 13148, “Greening the Government Through Leadership in Environmental Management” which stated in the Section 101 of E.O. 13148 that “the head of each Federal agency is responsible for ensuring that all necessary actions are taken to integrate environmental accountability into agency day-to-day decision-making and long-term planning processes, across all agency missions, activities, and functions.”

There are several goals of this E.O. 13148 that each federal agency needs to achieve, which are (directly from E.O. 13148 language):

- “Environmental Management: Each agency shall ensure that strategies are established to support environmental leadership programs, policies, and procedures and that agency senior level managers explicitly and actively endorse these strategies.”
• “Environmental Compliance: Each agency shall comply with environmental regulations by establishing and implementing environmental compliance audit programs and policies that emphasize pollution prevention as a means to both achieve and maintain environmental compliance.”

• “Right-to-Know and Pollution Prevention: Federal facilities shall be leaders and responsible members of their communities by informing the public and their workers of possible sources of pollution resulting from facility operations. Each agency shall strive to reduce or eliminate harm to human health and the environment from the release of pollutants to the environment. Each agency shall advance the national policy that, whenever feasible and cost-effective, pollution should be prevented or reduced at the source.”

• “Release Reduction: Toxic Chemicals: Each agency shall reduce its reported Toxic Release Inventory (TRI) releases and off-site transfers of toxic chemicals for treatment and disposal by 10 percent annually, or by 40 percent overall by December 31, 2006.”

• “Use Reduction: Toxic Chemicals and Hazardous Substances and Other Pollutants: Each agency shall reduce its use of selected toxic chemicals, hazardous substances, and pollutants, or its generation of hazardous and radioactive waste types at its facilities by 50 percent by December 31, 2006.”

• “Reductions in Ozone-Depleting Substances: Each agency shall develop a plan to phase out the procurement of Class I ozone-depleting substances for all nonexcepted uses by December 31, 2010.”
“Environmentally and Economically Beneficial Landscaping: Each agency shall strive to promote the sustainable management of Federal facility lands through the implementation of cost-effective, environmentally sound landscaping practices and programs to reduce adverse impacts to the natural environment.”

In 2007, Executive Order 13423, “Strengthening Federal Environmental, Energy, and Transportation Management”, was signed by President Bush. This order requires Federal agencies to implement the sustainable practices and to lead by example in advancing the nation’s energy security and environmental performance by achieving the following goals (directly from E.O. 13423 and U.S. EPA, 2007e):

- **Energy Efficiency:** Reduce energy intensity by 3 percent annually through the end of a fiscal year (FY) 2015 or 30 percent by the end of FY 2015, compared to an FY 2003 baseline.
- **Greenhouse Gases:** Reduce greenhouse gas emissions through reduction of energy intensity by 3 percent annually through the end of FY 2015 or 30 percent by the end of FY 2015, compared to an FY 2003 baseline.
- **Renewable Power:** At least 50 percent of current renewable energy purchases must come from new renewable sources (in service after January 1, 1999).
- **Building Performance:** Construct or renovate buildings in accordance with sustainability strategies, including resource conservation, reduction, and use; siting; and indoor environmental quality.
- Water Conservation: Reduce water consumption intensity by 2 percent annually through the end of FY 2015 or 16 percent by the end of FY 2015, compared to an FY 2007 baseline.
- Vehicles: Increase purchase of alternative fuel, hybrid, and plug-in hybrid (PIH) vehicles when commercially available.
- Petroleum Conservation: Reduce petroleum consumption in fleet vehicles by 2 percent annually through the end of FY 2015, compared to an FY 2005 baseline.
- Alternative Fuel: Increase use of alternative fuel consumption by at least 10 percent annually, compared to an FY 2005 baseline.
- Pollution Prevention: Reduce use of chemicals and toxic materials and purchase lower risk chemicals and toxic materials.
- Procurement: Expand purchases of environmentally sound goods and services, including biobased products, recycled content products, Energy Star ® products, water-efficient products.”

In 2009, Executive Order 13514, “Federal Leadership in Environmental, Energy, and Economic Performance”, was signed by President Obama. This order (in section 1: Policy) states that “Federal agencies shall increase energy efficiency; measure, report, and reduce their greenhouse gas emissions from direct and indirect activities; conserve and protect water resources through efficiency, reuse, and stormwater management; eliminate waste, recycle, and prevent pollution; leverage agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services; design, construct, maintain, and operate high performance sustainable
buildings in sustainable locations; strengthen the vitality and livability of the communities in which Federal facilities are located; and inform Federal employees about and involve them in the achievement of these goals.”

This order requires Federal agencies to meet a number of energy, water, and waste reduction targets, which are (directly from E.O. 13514 and Office of the Press Secretary, 2009):

- “Water Use Efficiency: Reduce water consumption intensity by 2 percent annually through FY 2020, or 26 percent by the end of FY 2020, compared to an FY 2007 baseline.
- Pollution Prevention: Divert at least 50 percent of non-hazardous solid waste, construction and demolition debris, by the end of FY 2015.
- Building Performance: Ensure that all new Federal buildings that enter the planning process are designed to achieve zero-net-energy by 2030.
- Petroleum Conservation: Reduce petroleum consumption in fleet vehicles by 2 percent annually through the end of FY 2020, compared to an FY 2005 baseline.
- Sustainable Acquisition: Ensure that 95 percent of all new applicable contracts will meet sustainability requirements.
- Development of guidance for sustainable Federal building locations in alignment with the Livability Principles put forward by the Department of
1.2 Overview of Environmentally Preferable Purchasing Plus Program (EPP+)

NASA Glenn Research Center (GRC) is one of the Federal agencies that initiated the implementation of the Environmentally Preferable Purchasing (EPP) Program. It established policies and procedures for implementing the program so as to promote and facilitate the purchase of environmentally-friendly and recycled products at GRC (NASA, 2008). By creating its own EPP program by the Environmental Management Office (EMO), which incorporated a unique Life Cycle Assessment (LCA) scoring system and also meeting the affirmative procurement (AP) criteria, GRC is calling this program, Environmentally Preferable Purchasing Plus or EPP+. This EPP+ program will be used for evaluating off-the-shelf products for use at GRC. The products that score highest in this program will be most strongly encouraged for purchase.

In order to complete the work of EPP+ program, the EPP+ evaluation model needed to be created. There were several steps that needed to be done as follows:

- Gathering the information for candidate products.
- Determining the category of the products that would be evaluated.
- Determining the scoring system for off-the-shelf products.
- Determining the rating procedure for off-the-shelf products.
- Using the concept of multiple-criteria decision-making with this model.
- Using the concept of sustainability with this model.
- Developing a web-based application for the EPP+ model.
• Testing a web-based application for the EPP+ model.
• Implementing the EPP+ program at GRC.

1.3 Goals of the Environmentally Preferable Purchasing Plus (EPP+) Program

There are 2 main goals for this EPP+ program at GRC.

1.3.1 Primary Goals

• To promote the purchase and use of products that support sustainable facilities:
  - Provides resource conservation benefits
  - Provides waste minimization benefits
  - Demonstrates stewardship (LCA)
  - Reduces regulatory compliance costs
  - Reduces the use of unsafe products
  - Reduces employee health risks
  - Reduces GRC environmental impacts
  - Provides opportunities for long-term cost savings
  - Serves all NASA facilities

1.3.2 Secondary Goals

• To promote the purchase of Affirmative Procurement (AP) products:
  - Recycled content
  - Biobased content
To promote the purchase and use of products that support sustainable government facilities, private industry and public consumers.

1.4 Problem Statement

The Environmentally Preferred Purchasing guidelines provided by the U.S. EPA state very clearly that the ideal approach to developing an EPP program would be by life cycle analysis/assessment (LCA). However, the EPA also admits on its website that it has not been able to achieve a life cycle assessment process. Therefore, the EPP+ system or this evaluation model at GRC, was developed using a combined quantitative/qualitative LCA scoring system.

The original EPP+ evaluation model had some limitations, which are as follows:

- The scoring of products is not widely available throughout the facility because the process for calculating the scoring of the products is done by using the spreadsheet program and stored in the evaluators or experts’ computers. For others to access this information, it requires the time to communicate between the evaluators and the person who wants this information.

- All of the product information, such as Material Safety Data Sheet (MSDS) of products, has been kept in hard copy forms or stored in the evaluators’ or experts’ computers. When disasters happen due to fire in the document storage room or if a computer crashes, this information will be lost and it will take time to obtain this information again.
• It is hard to promote the purchase of environmentally-friendly products throughout the facility to all employees and contractors since these product listings have been kept in one location.

• The current evaluation model does not support the multiple-criteria decision-making process for selecting the appropriate assessment factors that relate to the user’s needs.

It was clear that there was a need for developing a new EPP+ system that would include a web-based application that incorporates the multiple-criteria decision making process in order to overcome these limitations.

1.5 Research Objectives

The objective of this research was to design an evaluation model with a web-based application of an easy-to-use comprehensive computation of the LCA scoring system that can be used by the expert and non-expert personnel for determining the best environmentally-friendly off-the-shelf products that will be used at GRC. The goal is to overcome the limitations of the available models in the market and also incorporate the concept of multiple-criteria decision-making and sustainability to this model.

1.6 Methodology

To achieve the stated objective, this research has employed the following methodology:

• An extensive literature review has been conducted to identify previous work in this field and to identify limitations and challenges.
• The model has been developed to overcome the shortcomings and limitations identified through an extensive literature review.

• A scoring system has been created to be able to use in the web-based application.

• An intense study and practice in computer software development has been done in order to create the web-based application.

• An example has been employed to demonstrate the application of the model.

1.7 Organization of the Dissertation

The dissertation is organized as the following:

• Chapter 2 provides a literature review about the concepts of EPP, pollution prevention (P2), life cycle assessment (LCA), multiple-criteria decision making, and sustainability.

• Chapter 3 describes the model evaluation process and provides the information about rating and scoring of the assessment factors or criteria in this model.

• Chapter 4 describes the development of the web-based application of the model.

• Chapter 5 introduces an example of a model evaluation and discusses the results.

• Chapter 6 ends the dissertation with a summary and suggestions for future work.
CHAPTER II
LITERATURE REVIEW

2.1 Environmentally Preferable Purchasing (EPP) Concept

The E.O. 13101 requires that Federal agencies should follow the EPA’s guidance for the implementation of the EPP in their facility. The EPA encourages the agencies to buy the products that have fewer environmental and human health impacts and more environmentally friendly attributes, such as recyclable material, energy efficient equipment, etc. Moreover, it also stresses that those agencies should go further and considers multiple environmental effects of products in their entire life cycle.

There are many benefits of environmentally preferable purchasing program, which can be outlined as follows:

- Reducing negative impacts on the environment and on human health.
- Buying products that can be recycled helps keep the recycling programs running, which were developed to reduce the consumption of natural resources.
- Buying the products that are less toxic can help improve worker’s safety, reduce regulatory cost and reduce disposal cost.
• Buying the products that are reusable helps reduce waste, which in the long run will reduce the disposal and treatment cost. (U.S. EPA, 2007b)

2.1.1 **EPP Guiding Principles by EPA**

According to E.O. 13101, Federal agencies should consider the recovered materials and any environmentally preferable purchasing criteria developed by the EPA. Therefore, the EPA has developed five guiding principles to provide broad guidance for applying environmentally preferable purchasing in the Federal government setting. (U.S. EPA, 2007c)

The EPA (U.S. EPA, 2007a) stated that, “Applicability of these principles in specific acquisitions will vary depending on a variety of factors such as:

• The type and complexity of the product or service being purchased;
• The availability (commercial and non-commercial) of the product and service;
• The type of procurement method used (e.g., negotiated contract, sealed bid, etc.);
• The time frame for the requirement;
• The dollar amount of the requirement.

Also, in all acquisitions, Federal agency personnel use their professional judgment and common sense, whether assessing a product or service’s performance, cost, or availability. Similarly, in applying these environmentally preferable principles, Federal agency personnel should use reasonable discretion about the level of analysis needed to determine environmental preferability.”
The EPA five guiding principles for the EPP are as follows (directly from U.S. EPA 2007a):

1. “Environment + Price + Performance = Environmentally Preferable Purchasing (EPP)

   Environmental considerations should become part of normal purchasing practice, consistent with such traditional factors as product safety, price, performance, and availability.

2. Pollution Prevention

   Consideration of environmental preferability should begin early in the acquisition process and be rooted in the ethic of pollution prevention, which strives to eliminate or reduce, up-front, potential risks to human health and the environment.

3. Life Cycle Perspective/Multiple Attributes

   A product or service’s environmental preferability is a function of multiple attributes from a life cycle perspective.

4. Comparison of Environmental Impacts

   Determining environmental preferability might involve comparing environmental impacts. In comparing environmental impacts, Federal agencies should consider the reversibility and geographic scale of the environmental impacts, the degree of difference among competing products or services, and the overriding importance of protecting human health.

5. Environmental Performance Information
Comprehensive, accurate, and meaningful information about the environmental performance of products or services is necessary in order to determine environmental preferability.”

2.2 **Pollution Prevention Concept**

Pollution prevention is one of the five guiding principles of EPP; thus, knowing this term would help to understand the in-depth of EPP’s product evaluation process.

2.2.1 **Definition of Pollution Prevention (P2)**

Pollution prevention, or P2, is a term used to describe production technologies and strategies that result in eliminating or reducing waste streams. The EPA defines pollution preventions as, “the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous materials, energy, water or other resources and practices that protect natural resources through conservation or more efficient use” (U.S. EPA, 1991). Others (U.S. EPA, 2009) can define it as “reducing or eliminating waste at the source by modifying production processes, promoting the use of non-toxic or less-toxic substances, implementing conservation techniques, and re-using materials rather than putting them into the waste stream.”

In contrast to most pollution control strategies, which seek to manage a pollutant after it is formed and reduce its impact upon the environment, the pollution prevention approach seeks to increase the efficiency of a process, thereby reducing the amount of pollution generated as its source.
Pollution prevention activities range from product changes to process changes to changes in method of operation. This wide variety of activities is depicted in Figure 2.1 (Freeman, 1995).

**Figure 2.1 Typical source reduction methods. (Source: Bishop P., 2000)**
2.3 Life Cycle Assessment (LCA) Concept

Life cycle assessment (LCA) is one of the five guiding principles of EPP; thus, knowing more about this term would help to understand the in-depth of EPP’s product evaluation process.

2.3.1 Definition of Life cycle assessment (LCA)

The term, “Life cycle assessment” is defined in Section 211 of E.O. 13101 to mean “the comprehensive examination of a product’s environmental and economic aspects and potential impacts throughout its lifetime, including raw material extraction, transportation, manufacturing, use, and disposal.”


Also, the other easy to understand definition of LCA is an evaluation of the environmental effects associated with any given activity from the initial gathering of raw material from the earth until the point at which all residuals are returned to the earth (Vigon et al., 1993). Life cycle assessments are used to identify and measure both “direct” (e.g., emissions and energy use during manufacturing processes) and “indirect” (e.g., energy use and impacts caused by raw material extraction, product distribution, consumer use, and disposal) (Nash and Stoughton, 1994). A simple depiction of this can be seen in Figure 2.2.
Bishop (2000) stated that, “the systematic approach of LCA provides a true measure of the impact of a particular product or process. Unlike an environmental audit of an industrial process, which focuses on one particular facility and usually only on the activities that occur on the site, LCA looks at the linked interactions of the firm with the action of its suppliers and customers. The result is a total cradle-to-grave analysis of the environmental impact of a product.”

Bhat (1996) mentioned that, “LCA has been defined as an attitude through which manufacturers accept responsibility for the pollution caused by their products from design to disposal. This is a major change from the traditional philosophy that the
responsibility begins with the raw material acquisition and ends with the sale of the finished products.”

Life-cycle assessments can be used for a number of purposes. A survey (Breville et al., 1994) showed the motivations for conducting LCAs as presented in Figure 2.3.

![Figure 2.3 Motivations for implementing LCA. (Source: Bishop P., 2000)]
Foust and Gish (1996) mentioned that, “Life-cycle assessments performed for product and/or process improvement and/or cost reduction will remain the primary drivers; LCAs performed for cost reduction reasons will likely increase in the future, as waste disposal costs continue to increase. The second tier of motivators – decision making, proactive environmental positioning, and customer requirements – will continue as important drivers, with the last probably increasing. The other lower-tier drivers will vary slightly in significance but will probably remain as lower-tier drivers.”

2.3.2 Life cycle assessment (LCA) Methodology

The Society of Environmental Toxicology and Chemistry (SETAC) has been established, and refined the procedures of the components of the principal of life-cycle assessment.


- **Goal Definition and Scoping** – Define and describe the product, process or activity. Establish the context in which the assessment is to be made and identify the boundaries and environmental effects to be reviewed for the assessment.

- **Inventory Analysis** – Identify and quantify energy, water and materials usage and environmental release (e.g., air emissions, solid waste disposal, wastewater discharges) or conduct a Life Cycle Inventory (LCI).
- Impact Assessment – Assess the potential human and ecological effects of energy, water, and material usage and the environmental release identified in the inventory analysis.

- Improve assessment/Interpretation – Evaluate the results of the inventory and analysis and impact assessment to select the preferred product, process or service with a clear understanding of the uncertainty and the assumptions used to generate the results.”

These 4 components of LCA can be depicted in Figure. 2.4

![Figure 2.4 Components of a life cycle assessment. (Source: Bishop P., 2000)](image-url)
2.3.3  Resources and Tools for LCA

There are several software tools and packages available that have the capability to perform life cycle assessment. These are developed using the database of environmental information available for products. The choice of the software tool or the database will depend upon the definition and scope of the LCA to be performed, the category of the product, details needed for information of the life cycle of a product, the priorities of impact assessment and the design aspects of product, service or facilities. These tools follow the same principles, but differ depending upon where they are applied.

The following section will describe some examples of existing LCA tools that are available in the market. Some of these tools are designed and developed by the experts specifically for the LCA practitioners who are highly skilled in interpreting the information provided by these tools. These software tools are targeted for the experts working on the design of a specific product, service or even a facility (e.g. a building) that is targeted to be ecologically friendly.

2.3.3.1 Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI)

It is a software that was developed by the U.S. EPA. TRACI allows for the examination of the potential for impact associated with the raw material usage and chemical release resulting from the processes involved in producing a product. The impact categories that are evaluated in this software are, “ozone depletion, global warming, acidification, cancer, noncancer, criteria, eutrophication, smog formation,
ecotoxicity, fossil fuel use, land use, and water use” (Bare, 2002, Bare et al., 2003, and U.S. EPA, 2004).

2.3.3.2 Chain Management by Life Cycle Assessment (CMCLA)

It is a software developed by Centre of Environmental Science (CML) at Leiden University. It is a software tool that is intended to support the technical steps of the LCA procedure. (Leiden University, 2007).

2.3.3.3 Building for Environmental and Economic Sustainability (BEES 3.0)

It is a software developed by the National Institute of Standards and Technology (NIST) with the support of Building and Fire Research Laboratory and the EPA. The software is primarily used to measure or estimate the environmental impacts for a complete life cycle of building products. The tested version contains environmental and economical information for more than 200 building products. It is available for free to download from its website. (NIST, 2007).

2.3.3.4 Eco-Indicator 99

It is a software developed by PRe consultants in the Netherlands. It evaluates the environmental impacts and outputs a score for a product. It provides a complete assessment with details of fate, exposure, effect, and damage analysis. The damage categories considered are for human health, ecosystem and resource. (PRe Consultants, 2007a)
2.3.3.5 The Environmental Impact Estimator

It is a software developed by ATHENA Institute located in Canada. It is the only software tool in North America that evaluates whole buildings and assemblies based on LCA methodology (The Athena Institute, 2007). It allows the building designer to compare the alternative design of buildings by estimating the environmental impacts. The software comes with a large database of life cycle inventory. The environmental effects taken into consideration are material manufacturing and recycled content, transportation, on-site construction, variation in the use of energy by regions, type of building and its assumed life span, maintenance and repair effects, demolition and disposal, and operation energy emissions.

2.3.3.6 SimaPro 7 ®

It is a software developed by PRe consultants in the Netherlands. It is a professional software tool that contains several impact assessment methods and several inventory databases, which can be edited and expanded without limitation. It can compare and analyze complex products with complex life cycles. (PRe Consultants, 2007b)

2.3.3.7 TEAM ™

It is a software developed by Pricewaterhouse Coopers Ecobilan Group. It is a professional tool for evaluating the life cycle environmental and cost profiles of products and technologies. It contains comprehensive database of over 600 modules with worldwide coverage. (PCEG, 2007)
2.3.3.8 Umberto®

It is a software developed by the Institute for Environmental Informatics at Hamburg in Germany. Umberto serves to visualize material and energy flow systems. Data are taken from external information systems or are newly modeled and calculated. (IEI, 2007)

2.4 Multiple Criteria Decision Making (MCDM)

2.4.1 Overview of Multiple Criteria Decision Making (MCDM)

Zeleny (1998) stated that, “Multiple Criteria Decision Making (MCDM) is firmly rooted in an alternative concept of optimality where multiple (rather than single) criteria characterize the notion of “the best” (or optimal), as is prevalent in the areas of economics, engineering, management, and business.”

Mendoza and Prabhu (2000) stated that, “MCDM can be defined as a decision making tool that enables the rigorous selection of the most preferable choice in a context where several criteria apply simultaneously.”

Also, Mendoza and Prabhu (2000) stated that, “In a rational decision making environment, the most preferable choice is generally bounded to managerial objectives and the constraints that limit choice as well as the achievement of objectives. Consider the ease at which a decision, based on a single objective or criterion, is made. Assume that the choices or options relevant to that criterion are defined as: \(x_1, x_2, x_3, \ldots, x_n\). In addition, assume that the objective can be measured in terms of an objective value, represented by \(Z\). In a formal model, the decision making problem can be described as:

\[
\text{Optimize } Z = f(x_1, x_2, x_3, \ldots, x_n)
\]  

(1)

Where \(f(x_1, x_2, x_3, \ldots, x_n)\) is the function that gives the attainment value of the objective, given the choice. In this context, the problem can be described as: which of the options should be chosen in order to optimize the achievement of the objective.

MCDM is a simple extension of the problem described above. That is, instead of having only one objective or criterion based on a decision maker can make a choice among the different options, there are now multiple objectives or criteria to consider. Hence, the problem can be described as follows:

\[
\begin{align*}
\text{Optimize } Z_1 &= f(x_1, x_2, x_3, \ldots, x_n) \\
\text{Optimize } Z_2 &= f(x_1, x_2, x_3, \ldots, x_n) \\
\text{Optimize } Z_k &= f(x_1, x_2, x_3, \ldots, x_n)
\end{align*}
\]  

(2)

Where, \(Z_1, Z_2, \ldots, Z_k\) are the different criteria.
If all \( f_1, f_2, \ldots, f_k \) are known functions, the (2) is a special class of MCDM called multiple objective programming. If some of the \( f_i \) \((i = 1, 2, \ldots, k)\) are best described as discrete non-functional relationships, (2) is generally referred to as multi-attribute decision making. Most often, the criteria are expressed as attributes which can be quantitative, qualitative, or both.

In applying MCDM within the framework of the criteria and indicators (C&I) measurements for assessing environmentally preferable purchasing products, with life cycle assessment and sustainability of products, the criteria; \( Z_1, Z_2, \ldots, Z_k \), take the form of discrete attributes and are not defined as continuous functional relationships. Instead, they take general qualitative forms some of which are measurable directly or implicitly, while others are inherently qualitative and defy formal quantification. Likewise, the indicators under each criterion can also be both quantitative and/or qualitative.

MCDM has desirable characteristics that make it suitable for the EPP+ by giving it a set of C&I parameters. These features include:

- Capability to accommodate multiple criteria in the analysis.
- It is participative, allowing the direct involvement of multiple experts, interest groups or stake holders.
- Analysis need not be data intensive. In fact, the procedure can be used with a minimal amount of information. In some cases, expert opinions may be used in the absence of adequate data.
- MCDM can work with mixed data. It allows for the incorporation of both qualitative and quantitative information. Qualitative information can be both
pseudo-quantifiable (by using proxy measures) and/or inherently non-quantifiable.

- The analysis is transparent to participants.

In the context of the C&I hierarchy described in Figure 2.5, the MCDM decision problem may now be viewed as a process involving the determination of the relative importance of each C&I element relative to the higher levels of the hierarchy. Insights gained from this analysis can be used in a variety of ways:

- prioritization of principles in terms of their significance to overall EPP+,
- prioritization of criteria under each principle; and
- prioritization of indicators under each criterion.

These prioritized lists can be used to: (1) guide decisions relative to what criteria and/or indicators are considered significant, and must be examined in the EPP+ program in light of limited resources and time constraints; and (2) focus on those criteria and indicators that are considered most significant where the performance of the EPP+ product is found lacking.”
2.4.2 Multiple Criteria Decision Making (MCDM) Methodology

Mendoza and Prabhu (2000) stated that, “There are three MCDM methodologies that could be used in C&I assessment:

1. *Pairwise comparisons method*

   This approach distills the complex C&I decision problem into a series of one-on-one judgment regarding the significance of each pair of indicators relative to one criterion.

2. *Ranking method*

   This approach is different from the pairwise comparison method in that C&I elements are not compared one-on-one. Instead, they are judged by their degrees of importance and are then give ranks accordingly.

3. *Rating method*

   It is like the ordinal ranking method, in that all indicators are judged by their relative degrees of importance, indicated by ‘scores’ instead of cardinal ranking.”
2.5  Sustainability Concept

2.5.1  Definition of Sustainability

The term, “sustainability” and “sustainable” is defined in Section 19 (l) of E.O. 13514 to mean “create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations”. The terms, sustainable development and sustainability, are used interchangeably throughout this research.

Over the past 30 years, the concept of sustainability has evolved to reflect perspectives of both the public and private sectors. A public policy perspective would define sustainability as the satisfaction of basic economic, social, and security needs now and in the future without undermining the natural resource base and environmental quality on which life depends. From a business perspective, the goal of sustainability is to increase long-term shareholder and social value, while decreasing industry’s use of materials and reducing negative impacts on the environment.

This is a goal of the EPP+ tool and the software protocol developed under this dissertation. If the EPP+ concept and product listings are used and expanded into more geographic regions, this would aid in achieving a sustainable economy.

2.5.2  Criteria for Choosing Measures

Mortensen (1998) stated, “When attempting to measure sustainable development, or progress made towards it, it is important to focus on aspects that effectively capture the essence of the issue. The multitude of aspects contained in this concept makes it
necessary to address only those aspects that are of particular importance. Furthermore, the measurement of sustainable development is obviously contingent upon the availability of necessary data.

Various criteria have been developed by organizations, governments, and others in an attempt to measure sustainable development. In recent years the following criteria have been used by various organizations and governments (United Nations, 1996b; OECD, 1994):

- relevant: the phenomenon measure should have direct relevance to sustainable development;
- understand: the measures should be simple, clear and unambiguous;
- conceptual: the measures should be conceptually well-founded;
- limited: the measures should be limited in number, remaining open-ended and adaptable to future developments;
- data available: necessary data should be readily available or available at a reasonable cost-benefit ratio, adequately documented, of known quality, and updated at regular intervals.

The criteria to be adopted in a given situation depend on the specific purpose of the measurements to be made within the context of that situation. Therefore, some measures may be used at the national level, others at the local level. However, the criteria listed above give good and comprehensive guidance for developing measures of sustainable development.”
2.5.3 Measure of Sustainable Development


- **Environmental aspects**

  Environmental aspects of sustainable development include the following among others: the atmosphere, oceans, fresh water, forests, agriculture, land resources, biodiversity, chemicals and natural resources. All these are key environmental issues with implications for the ability of human societies to move towards a more sustainable development pattern. Examples of environmental measures are numerous; some of those used at the national level are concerned with pesticides and fertilizers, protected forests, land-use change, emissions of greenhouse gases, waste generation, and protected species (United Nations, 1996a)

- **Economic aspects**

  Economic measures are routinely used by other decision-makers everywhere in the world. The best known example of such a measure (index) is the Gross Domestic Product (GDP), which together with its variants such as the Gross National Product (GNP) and the Gross National Income (GNI), is widely used as the primary macroeconomic measure of a country’s economic performance. Other economic measures, such as rate of inflation, money supply, etc., are also routinely used to check the economic health of a country everywhere in the world.
• **Social aspects**

Some social measures, such as measure of population, health and education, are relatively well developed and used all over the world. However, adequate measures for other social aspects of sustainable development are still to be developed and used on a wide scale. They include poverty (income does not cover the issue adequately), civic life, human well-being, and cultural values. It is pointed out that some of the measures, referred to as social measures, are sometimes known as ‘human’ or ‘cultural’ measures.”

For sustainability to be successful, economic, environmental, and social aspects must be considered together, since they are inextricably linked.
CHAPTER III

EPP+ MODEL EVALUATION PROCESS

3.1 Overview

This chapter will describe, modify, and summarize the procedure on EPP+ evaluation process based on “Guidelines for Purchasing Products: Under Affirmative Procurement (AP) and Environmentally Preferable Purchasing (EPP)” that are used at the GRC (Kocher, W.M. and Sekura, L., 2006). Since the development of the EPP+ web-based application will be used only at NASA, GRC, it is necessary to study the requirements and the basic concept that will be using in this evaluation process.

These EPP+ implement procedure processes at GRC can be depicted in Figure 3.1.
Figure 3.1 EPP+ Implementation Procedure (Source: Kocher, W.M. and Sekura, L., 2006)
At the present time, there are 10 product categories that the EPA has been categorized in the EPP program. These 10 product categories are as follows:

- Building and construction
- Carpets
- Cleaning
- Electronics
- Fleets
- Food services
- Landscaping
- Meetings and conferences
- Office supplies
- Paper

In each product category, environmental attributes and procurement guidance will be provided to each category.

Since NASA, GRC has its own product categories, the development of the EPP+ will focus on the guidelines that were created by the Environmental Management Office (EMO) at NASA, GRC.

At present, the EPP+ program at NASA, GRC has 5 product categories. They are as follows:

- Cleaners; light-duty cleaners, heavy-duty degreasers, parts washers & degreasers, precision cleaners, electrical contact cleaners, defluxers
- Paints, Coatings, Adhesives; Paints, paint touch-up – aircraft, paint removers, coating removers, adhesive removers
• Machining fluids; Lubricants, coolants, dyes, cutting fluids
• Automotive or Fleet Products; Automotive degreasers, brake cleaners, tire glue, tire beadsealer, A/C flush solvent
• Home & Janitorial Products; Light-duty cleaners, adhesives, adhesive removers, paints, paint removers, toilet bowl cleaners

The products currently used by NASA, GRC that contain ingredients threatening to health, environment and safety will be targeted for possible replacement by the EPP+ program. Also, the products that contain the restricted listings of chemicals (such as those hazardous to the environment or those that contain carcinogen potential ingredients, etc) will require a waiver form that they are absolutely required to use. Thus, these products which contain the restricted listing of chemical will not be evaluated in the EPP+ process, if they do not fill out the form.

Once the potential replacement products or candidate products are selected, which can be obtained from the approved lists of agency environmental catalogs such as the General Services Administration (GSA) catalogs, the detailed information of these products needs to be obtained whether by manufacturer or other sources. For example, selecting products in the cleaner category that contain many chemicals may require the manufacturer MSDS (Material Safety Data Sheet), TDS (Technical Data Sheet), CASRN (Chemical Abstract Services Registry Number), etc. After detailed information of the selected product is obtained, the product will be reviewed and scored for 8 assessment factors or criteria which are

• Affirmative Procurement; Recycle content, Bio-based products
• Performance: Applicability and Performance Record
• Price: Capital Costs, Operations & Maintenance Costs, Payback Period
• Meeting Goals: Recycle Potential, Solid Waste Minimization, Hazardous Waste Minimization
• Conservation: Water Use Reduction, Energy Use Reduction, Other Resource Reduction
• Facility Environmental, Health and Safety (EHS): Environmental Emissions, Health Risk Benefit, Safety Hazard Benefit
• Environmental Impact Potential: Bioaccumulation, Environmental Damage, Global Issues
• Compliance: Regulatory Benefit, Executive Order (EO) & Policy Benefit, Reduction of Liabilities

The weighting factors will be decided by a P2 (Pollution Prevention) team and will be given a scoring assessment of each factor or criteria based on the product-use category. The value of the weighting factors will vary between 0.0 and 1.0. These weighting factors represent the relative importance of each assessment factor or criteria. For example, for a product that cleans a critical aerospace part, all the weighting factor under the performance assessment factors may be 1.0, and other factors might be reduced to reflect the priorities. For heavy-duty cleaning products, the weighting factor under the health, safety, environmental issues and price may be given high factor values, and performance factors might be reduced.

After the weighting factors have been assigned to each assessment factor of the selected product, the calculation of the score for the product will be input on the scoring worksheet. The score of the selected product is calculated by multiplying the weighting
factors to an assigned numeric rating score, which ranges from 0 to 5 in each assessment factor. The detail of the rating score will be described in the next section.

The complete scoring worksheet of the off-the-shelf products that have been reviewed and scored by the EPP+ personnel will be submitted to the department director.

3.2 Product Rating Guidelines

All the potential replacement products that have been selected for the EPP+ program will be given a score for each assessment factors by numerical rating score. These numerical ratings range from 0 to 5, where 0 means the least desired and 5 means the most desired.

3.2.1 Affirmative Procurement (AP)

The Affirmative Procurement (AP) program is a program that regulated the Federal agencies, including NASA, to purchase products made with recovered and recycled materials. Therefore, this is the first assessment factor that will be consider in the EPP+ program.

There are two criteria of AP standards that will be using to determine this first assessment factor: recycled content and biobased content.

3.2.1.1 Recycled Content

Based on the definition by the Federal Trade Commission (FTC) and the Environmental Protection Agency (EPA), “recycled” products are defined as, “the products that are made from items recovered or separated from the “waste stream” that
are melted down or ground up into raw materials and then used to make new products” (FTC, 1999).

**Rating Guideline of Recycled Content**

For each product, find the minimum threshold for meeting EPA-designate recycled content targets for the type of product you want to buy. Then, give each product a rating against that threshold (target).

**Table 3.1: Rating guidelines for the recycled content of product**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Contains the following % or threshold recycled content for product category</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Above 50% of recycled contents</td>
</tr>
<tr>
<td>4</td>
<td>Above 25% and up to 50% of recycled contents</td>
</tr>
<tr>
<td>3</td>
<td>Above AP threshold value and up to 25% of recycled contents</td>
</tr>
<tr>
<td>2</td>
<td>Equal AP threshold value of recycled content</td>
</tr>
<tr>
<td>1</td>
<td>Below AP threshold value of recycled content</td>
</tr>
<tr>
<td>0</td>
<td>Product does not contain recycled or reclaimed materials</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided as follows:

For rating a product in the “paper” category, 30% of recycled content in the paper is required for this type of product by EPA’s paper purchasing guideline for recycled content of AP. Therefore, a paper product that contains 30% of the recycled content will be given a rating score of 2. Or a paper product that contains 40% of the recycled content will be given a rating score of 4, the percentage of the recycled content of a selecting product (40%) subtracted by the AP percentage threshold (30%) and divided by the AP percentage threshold (30%) times 100 equals to 33% more than the AP percentage threshold that in this case falls into rating equals to 4.
3.2.1.2 Biobased Content

As defined in Executive Order 13101, “Biobased product” means, “a commercial or industrial product (other than food or feed) that utilizes biological products or renewable domestic agricultural (plant, animal, and marine) or forestry materials.”

Rating Guideline of Biobased Content

For each product, find the minimum threshold for meeting EPA- or USDA-designate biobased content targets for the type of product you want to buy. Then, give each product a rating against that threshold (target)

Table 3.2: Rating guidelines for the biobased content of product

<table>
<thead>
<tr>
<th>Rating</th>
<th>Contains the following % or threshold biobased content for product category</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Above 50% of biobased contents</td>
</tr>
<tr>
<td>4</td>
<td>Above 25% and up to 50% of biobased contents</td>
</tr>
<tr>
<td>3</td>
<td>Above AP threshold value and up to 25% of biobased contents</td>
</tr>
<tr>
<td>2</td>
<td>Equal AP threshold value of biobased content</td>
</tr>
<tr>
<td>1</td>
<td>Below AP threshold value of biobased content</td>
</tr>
<tr>
<td>0</td>
<td>Product does not contain biobased materials</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided as follows:

For rating a product in the “cleaning” category, 30% of biobased content in the cleaning product, if it is citrus based, is required for this type of product by USDA’s cleaning product purchasing guideline for biobased content of AP. Therefore, a cleaning product that contains citrus based product that contains 30% of the biobased content will be given a rating score of 2. Or a cleaning product that contains citrus based product that contains 50% of the biobased content will be given a rating score of 5, the percentage of the biobased content of a selecting product (50%) subtracted by the AP percentage.
threshold (30%) and divides by the AP percentage threshold (30%) times 100 equals to 67% more than the AP percentage threshold that in this case falls into rating equals to 5.

### 3.2.2 Performance

This category would be a measurement of the product performance. There are two criteria of performance product measurement that will be using to determine this second assessment factor: applicability and performance record.

#### 3.2.2.1 Applicability

This will rate the product on its effective use for similar purposes (versus its performance for the purpose intended) either at NASA, military applications, or industrial uses similar to NASA use.

**Rating Guideline of Applicability**

The products that are used effectively at NASA facility would be rated at the highest score; in this case, it would be 5. The rest of the score will be related to the application of the product to the other facility.

**Table 3.3: Rating guidelines for the applicability**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Products has been used effectively:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>At NASA facilities</td>
</tr>
<tr>
<td>4</td>
<td>At other federal facilities</td>
</tr>
<tr>
<td>3</td>
<td>For industrial uses</td>
</tr>
<tr>
<td>2</td>
<td>For miscellaneous uses</td>
</tr>
<tr>
<td>1</td>
<td>Product with no clear track record</td>
</tr>
<tr>
<td>0</td>
<td>Product still in research and development stage</td>
</tr>
</tbody>
</table>
3.2.2.2 Performance Record

This will rate the product on its effective use especially, for the purpose intended, either at NASA, military applications, or industrial uses similar to NASA use.

Rating Guideline of performance record

The rating would be referred to the most desirable products that have been tested and verified by NASA for effectiveness of the product.

Table 3.4: Rating guidelines for the performance record

<table>
<thead>
<tr>
<th>Rating</th>
<th>Products has been tested and:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Verified for effective uses at NASA</td>
</tr>
<tr>
<td>4</td>
<td>Verified for effective uses at similar facilities</td>
</tr>
<tr>
<td>3</td>
<td>Produced positive test results for categorical uses</td>
</tr>
<tr>
<td>2</td>
<td>Produced mixed test results for categorical uses</td>
</tr>
<tr>
<td>1</td>
<td>Product has not been tested</td>
</tr>
<tr>
<td>0</td>
<td>Product has been tested but give very poor test result</td>
</tr>
</tbody>
</table>

3.2.3 Price

There are three criteria of price of the product category that will be used to determine this third assessment factor: capital costs, operation & maintenance (O&M) costs, and payback period.

3.2.3.1 Capital Costs

This would include the initial price of the product itself, including any initial necessary supplies, transportation and handling, installation, and taxes and insurance. The
costs may also reflect initial compliance costs that are not always obvious to product users.

**Rating Guideline of capital costs**

Compare all the products in this category and determine the product that has the highest total capital costs. The highest total capital costs product will be used as the 100% level. Then, compare the percentage of difference of each product to the highest total capital costs product.

**Table 3.5: Rating guidelines for capital costs**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Comparison of the percentage of the product to the highest capital cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Product has no capital costs</td>
</tr>
<tr>
<td>4</td>
<td>Product has minimal costs and up to 20%</td>
</tr>
<tr>
<td>3</td>
<td>More than 20% and up to 40%</td>
</tr>
<tr>
<td>2</td>
<td>More than 40% and up to 60%</td>
</tr>
<tr>
<td>1</td>
<td>More than 60% and up to 80%</td>
</tr>
<tr>
<td>0</td>
<td>More than 80%</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided by following:

For rating the capital costs of a product in the “cleaning” category, assuming the highest capital costs of the product in the “cleaning” category is $10,000, the capital costs for replacement cleaning “A” is $4,000. Compare the percentage of the capital costs of cleaning “A” to the highest capital costs product by dividing the capital costs of cleaning “A” ($4,000) with the amount of the highest capital costs product ($10,000) and then times 100, the result would be 40% compare to the highest capital costs. 3 would be the rating of this product. The highest capital costs product would automatically be rated at 0.
Operation and Maintenance Costs (O&M)

The O&M costs and considerations will include the following:

- Supplies
- Storage/expiration/price breaks
- Cleanup, including hazardous waste
- Training-labor & materials
- Maintenance & repair (durability)
- Recovery/reuse/remanufacture/recycling
- Personal protection equipment
- Other indirect costs
- Treatment/disposal
- Enhanced productivity
- Costs associated with compliance
- Cost of waste minimization efforts
- Regulations – permits
- Potential liabilities – non-regulatory
- Emergency management
- Property tax & insurance
- Utilities and resources
- Record-keeping/paperwork processing
- Medical surveillance
Rating Guideline of Operation and Maintenance (O&M) Costs

Compare all the products in this category and determine the product that has the highest total O&M costs. The highest total O&M costs product will be used as the 100% level. Then, compare the percentage of difference of each product to the highest total O&M costs product.

Table 3.6: Rating guidelines for operation and maintenance (O&M) costs

<table>
<thead>
<tr>
<th>Rating</th>
<th>Comparison of the percentage of the product to the highest O&amp;M cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Product has no O&amp;M costs</td>
</tr>
<tr>
<td>4</td>
<td>Product has minimal costs and up to 20%</td>
</tr>
<tr>
<td>3</td>
<td>More than 20% and up to 40%</td>
</tr>
<tr>
<td>2</td>
<td>More than 40% and up to 60%</td>
</tr>
<tr>
<td>1</td>
<td>More than 60% and up to 80%</td>
</tr>
<tr>
<td>0</td>
<td>More than 80%</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided by the following:

For rating the O&M costs of a product in “cleaning” category, assuming the highest annually O&M costs of the product in “cleaning” category is $10,000, the annually O&M costs for replacement cleaning “A” is $2,000. Compare the percentage of the annually O&M costs of cleaning “A” to the highest annually O&M costs product by dividing the annual O&M costs of cleaning “A” ($2,000) with the amount of the highest annually O&M costs product ($10,000) and then times 100, the result would be 20% compare to the highest annually O&M costs. 4 would be the rating of this product. The highest annually O&M cost product would automatically be rated at 0.
3.2.3.2 Payback Period

The payback period in the easy to understand concept is the length of time that something takes to pay for itself. It is often widely used with the energy efficiency products.

Rating Guideline of Payback Period

Compare initial cost of the product to the cost of annual saving. The shorter payback periods are preferable to longer payback periods.

Table 3.7: Rating guidelines for payback period

<table>
<thead>
<tr>
<th>Rating</th>
<th>Payback period (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Up to 1 year</td>
</tr>
<tr>
<td>4</td>
<td>More than 1 year and up to 2 year</td>
</tr>
<tr>
<td>3</td>
<td>More than 2 year and up to 3 year</td>
</tr>
<tr>
<td>2</td>
<td>More than 3 year and up to 5 year</td>
</tr>
<tr>
<td>1</td>
<td>More than 5 year and up to 10 year</td>
</tr>
<tr>
<td>0</td>
<td>More than 10 year</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided by following:

For rating the payback of a product in the “electronics” category, first of all, compare the difference between a new high efficiency energy product and an inefficiency energy product. Second, compare the difference between an annual energy cost with inefficiency energy product and high efficiency energy product. Then, calculate the payback period by dividing the difference of the two products costs (efficiency and inefficiency energy) by the different of the two annual energy costs. Assuming the cost of a new high efficiency energy product is $10,000 and the existing (inefficiency) energy product is $8,000, the difference for this cost would be $2,000. Then, assuming the
annual energy cost of the existing (inefficiency) product is $2,000 and the annual energy cost of the new high efficiency product is $1,000, the annual energy saving would be $1,000. Therefore, the payback period would be 2 years [$2,000/$1,000/year], which is why this product would be rated at 4.

3.2.4 Meeting Goals

These goals are consistent with Executive Order, NASA policies, and ISO 14000 criteria. There are three main goals which have been the focus of NASA’s effort to meet with. These three goals are recycle potential, solid waste minimization and hazardous waste minimization.

3.2.4.1 Recycle Potential

Recyclable products can be collected and remanufactured into new products after they have been used. These products do not necessarily contain the recycled material, and only benefit the environment if people recycle them after use. The product should not be rated as recyclable if the facility, NASA, has no intention of or capability to recycle it. The recycle potential opportunity would include some of the following factors: costs and time to find a recycler and for ongoing delivery/pickup, storage, handling/transportation costs, record-keeping, and potential liabilities regarding to the reuse of the product and final disposal.

Rating Guideline of Recycle Potential

The qualitative measurement would be used to determine the amount of costs and effort that will offset the benefit in recycle potential. This is one of the most subjective
categories, and should involve the most input from those, such as a recycling program, that will physically be handling the ongoing recycling efforts.

**Table 3.8: Rating guidelines for recycle potential**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Recycle potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Very High</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Significant</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
</tr>
<tr>
<td>1</td>
<td>Poor</td>
</tr>
<tr>
<td>0</td>
<td>Product cannot be recycled</td>
</tr>
</tbody>
</table>

3.2.4.2 **Solid Waste Minimization**

The most desirable products in this category would have the greatest potential for minimizing solid waste generation at NASA. The reduction of landfill space or landfill need is the main idea for this objective. For the most part, NASA’s solid waste will consist of paper and packaging, gloves and other personal protection equipments, and supplies.

The solid waste minimization criteria would include some of the following factors: the degree of biodegradability, concentration, landfill reduction, personal protective equipments, supplies, packaging of the product and manufacturer practices.

**Rating Guideline of Solid Waste Minimization**

The qualitative measurement would be used to determine all the factors that are related in the solid waste minimization criteria. The subjective judgment will need to be used for rating these factors.
Table 3.9: Rating guidelines for solid waste minimization

<table>
<thead>
<tr>
<th>Rating</th>
<th>Solid waste minimization potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Very High</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Significant</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
</tr>
<tr>
<td>1</td>
<td>Poor</td>
</tr>
<tr>
<td>0</td>
<td>Product offers no solid waste minimization potential</td>
</tr>
</tbody>
</table>

3.2.4.3 Hazardous Waste Minimization

Hazardous waste is waste that is dangerous or potentially harmful to someone’s health or the environment. Hazardous wastes can be many forms: solids, liquids, gases, or sludges. The discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes, are some hazardous waste examples.

For our purposes, if waste is hazardous under the federal guidelines, or state, local, or NASA guidelines, it will be considered in this category.

The hazardous waste minimization criteria would include some of the following factors: the degree of corrosivity, ignitability or flammability, reactivity, toxicity, HAP/RCRA/SARA/CERCLA listed waste, state reporting, and manufacturer processing/practices.

Rating Guideline of Hazardous Waste Minimization

The qualitative measurement would be used to determine all the factors that are related in the hazardous waste minimization criteria. The MSDS sheets of the products would provide the degree measurement of hazardous waste characteristics: corrosivity, ignitability or flammability, reactivity, toxicity. This information may be represented by
the hazard rating standard maintained by the U.S.-based National Fire Protection Association (NFPA) or the Hazardous Materials Identification System (HMIS). The rating for these criteria may be interpreted as the higher degrees of these hazardous waste characteristics in the products and the lower rating in the hazardous waste minimization potential.

Table 3.10: Rating guidelines for hazardous waste minimization

<table>
<thead>
<tr>
<th>Rating</th>
<th>Hazardous waste minimization potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Very High</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Significant</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
</tr>
<tr>
<td>1</td>
<td>Poor</td>
</tr>
<tr>
<td>0</td>
<td>Product offers no hazardous waste minimization potential</td>
</tr>
</tbody>
</table>

3.2.5 Conservation

There are three main criteria in this assessment factor. They are the conservation of energy, water and other resources. The reduction or elimination of the use of resources is the main focus for this assessment factor. If a product or resource is eliminated, it also eliminates the need (and additional resources) to reuse and recycle.

3.2.5.1 Energy Use Reduction

The most desirable products in this category would lead to the greatest reduction in energy usage at NASA. Look at how the product is formulated and how it will be used, and, if possible, how it is manufactured. Determine the type of energy use for the products in order to compare to the right standards. For examples, the product purchasing guideline for the Federal agencies to purchase the products in the “electronics” category
should follow the Energy Policy Act of 2005, which requires Federal agencies to buy either ENERGY STAR products or products designated as energy efficient by the Federal Energy Management Program (FEMP).

**Rating Guideline of Energy Use Reduction**

The qualitative measurement would be used to determine the energy use reduction.

**Table 3.11: Rating guidelines for energy use reduction**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for energy use reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Very High</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Significant</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
</tr>
<tr>
<td>1</td>
<td>Poor</td>
</tr>
<tr>
<td>0</td>
<td>Product offers no energy use reduction potential</td>
</tr>
</tbody>
</table>

**3.2.5.2 Water Use Reduction**

The most desirable products in this category would have the greatest reduction in water usage at NASA. Determine the water use of the products, if applicable, in the products life cycle stages.

**Rating Guideline of Water Use Reduction**

The qualitative measurement would be used to determine the water use reduction.

**Table 3.12: Rating guidelines for water use reduction**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for water use reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Very High</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Significant</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
</tr>
<tr>
<td>1</td>
<td>Poor</td>
</tr>
<tr>
<td>0</td>
<td>Product offers no water use reduction potential</td>
</tr>
</tbody>
</table>
3.2.5.3 Other Resources Use Reduction

The most desirable products in this category would have the greatest reduction in other resources usage at NASA. The focus should be on elimination of the use of non-renewable resources like petroleum derived, or especially old-growth forest and rainforest products, animal-derived products, and the reduction of renewable resource use.

**Rating Guideline of Other Resources Use Reduction**

The qualitative measurement would be used to determine the other resource use reduction.

**Table 3.13: Rating guidelines for other resources use reduction**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for other resources use reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Very High</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Significant</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
</tr>
<tr>
<td>1</td>
<td>Poor</td>
</tr>
<tr>
<td>0</td>
<td>Product offers no other resources use reduction potential</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided as follows:

For rating a product in “cleaning” category, if the product is citrus-based with little added chemical content and no petroleum derivatives, 4 or 5 would be a rating for this product. Also, if a product contains a petroleum derivative with a strong smell and high color additives, 0 or 1 would be a rating for this product.
3.2.6 Facility Environment, Health, and Safety (EH&S)

In this assessment factor, there are three criteria to be evaluated. They are environmental emissions, health risks benefits, and safety hazards benefits. The focus is on within-facility everyday standard use (versus accidental), i.e., expected emissions, health, and safety issues, for any exposure route (air, water, soil, skin contact). There are several groups of organization within NASA that are responsible for these subjects. They are the Executive Safety Board (ESB) within the Glenn Safety Organization (GSO), Labor Management Safety and Health Council (LMSHC), the Office of Safety and Assurance Technologies (OSAT), Environmental Management Office (EMO), and Security Management Office (SMO).

3.2.6.1 Environmental Emissions

The most desirable products in this category would provide the greatest environmental protection benefits and the largest reduction in pollutant release at NASA. The reduction of the pollutant release means the reduction of air emissions, water emissions or releases, and secondary pollutants. The most common chemicals that produce secondary pollutants are VOCs (volatile organic compounds), sulfur dioxide (usually indicated as SOx), and oxides of nitrogen (usually indicated as NOx).

Rating Guideline of Environmental Emissions

The qualitative measurement would be used to determine all the factors that are related in the environmental emissions criteria. The MSDS sheets of the products sometimes provide the details in ecological information, toxicity to wildlife, ecotoxicity,
environmental fate, disposal considerations, or control measures. Use this information of the products to be rated.

Table 3.14: Rating guidelines for environmental emissions

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for positive environmental benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>Limited</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>0</td>
<td>Product does not provide positive environmental benefits</td>
</tr>
</tbody>
</table>

3.2.6.2 Health Risks Benefits

The most desirable products in this category would provide the greatest reduction in health risks due to the use of the product at NASA. Consideration should be given to potential inhalation, skin contact (including absorption), eye exposure, and ingestion. The health risks benefits criteria would consider the following factors:

- Carcinogens
- Neurotoxins
- Immunotoxins
- Developmental/reproductive toxins
- Other toxins
- Irritants
- Sensitization
- Others, including odor
- OSHA/ACGIH/NIOSH regulated
• Industrial Hygiene (IH)/ Chemical Management Team (CMT) additional lists

**Rating Guideline of Health Risks Benefits**

The qualitative measurement would be used to determine the health risks benefits. The information of the toxicological of the products can be found from the MSDS sheets of the products or from the products’ websites. Also, check under Hazard Identification for irritation/sensitization, and under Potential Health Effects. The National Institute for Occupational Safety and Health (NIOSH), the American Conference of Governmental Industrial Hygienists (ACGIH), and the American Industrial Hygiene Association (AIHA) pocket guides of the products would give the products’ chemical components.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for health risks benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>Limited</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>0</td>
<td>Product does not provide health risks benefits</td>
</tr>
</tbody>
</table>

**3.2.6.3 Safety Hazards Benefits**

The most desirable products in this category would provide the greatest reduction in safety hazards due to the use of the product at NASA. This includes non-chemical (non-health) hazards employees may be exposed to. Non-chemical hazards would include flammability, reactivity (possibility of combustion/explosion/burns), and corrosivity. Also, a chemical’s pH of the product is a good indicator of reactivity.
Rating Guideline of Safety Hazards Benefits

The qualitative measurement would be used to determine the safety hazards benefits. There are many sections from the MSDS sheets of the products that provided the information of physical and chemical properties (pH, flammability, etc), handling and storage, exposure controls & PPE, stability and reactivity, which can help in order to rate the products in this criteria.

Table 3.16: Rating guidelines for safety hazards benefits

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for safety hazards benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>Limited</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>0</td>
<td>Product does not provide safety hazards benefits</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided as follows:

For rating a product in “cleaning” category, if the product contains pH in the neutral range (about 7) and is listed as a combustible product, 2 or 3 would be a rating for this product. Also, if a product is very high acidic or basic and is listed as a combustible product, 0 or 1 would be a rating for this product.

3.2.7 Environmental Impact Potential

Compared to the evaluation of the environmental emissions in the section of “Facility EH&S”, which dealt with everyday emissions from standard use, the focus of
this assessment factor is on the potential for local and global environmental damage based on accidental releases.

There are three criteria that will be evaluated in this assessment factor. They are bioaccumulation, environmental damage (local), and global issues.

### 3.2.7.1 Bioaccumulation

Bioaccumulation is a function of the bioavailability of contaminants in combination with species-specific uptake and elimination process (EPA, 2000). It refers to the accumulation of substances, such as pesticides or other organic chemicals, in an organism or part of an organism (USGS, 2008).

PBT (persistent bioaccumulative toxic) chemicals or compounds will be used as an indicator for evaluating this criteria.

There are 16 PBT chemicals and 4 PBT chemical compound categories that are subject to reporting under the EPCRA (Emergency Planning and Community Right-to-Know Act) section 313:

- 4 PBT chemical compound categories:
  - Dioxin and dioxin-like compounds
  - Lead compounds
  - Mercury compounds
  - Polycyclic aromatic compounds (PACs)

- 16 PBT chemicals:
  - Aldrin
  - Benzo(g,h,i)perylene
- Chlordane
- Heptachlor
- Hexachlorobenzene
- Isodrin
- Lead
- Mercury
- Methoxychlor
- Octachlorostyrene
- Pendimethalin
- Pentachlorobenzene
- Polychlorinated biphenyl (PCBs)
- Tetrabromobisphenol A
- Toxaphene
- Trifluralin

The most desirable products in this category would provide the greatest bioaccumulation benefits and the largest reduction in pollutant releases at GRC.

**Rating Guideline of Bioaccumulation**

The qualitative measurement would be used to determine the potential for positive bioaccumulation benefits. The BCF (bioconcentration factor) rating will be used in order to determine the level of PBT or other chemicals. The information of BCF can be obtained from the MSDS sheets of the products. Products that may contain PBT chemicals/compounds will be considered to have the potential for significant adverse
environmental effects if they have either a measured bioconcentration factor (BCF) equal to or greater than 1000. The lower lever of the BCF of the chemicals, the better the positive bioaccumulation benefits.

**Table 3.17: Rating guidelines for bioaccumulation**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for positive bioaccumulation benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>Limited</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>0</td>
<td>Product does not provide positive bioaccumulation benefits</td>
</tr>
</tbody>
</table>

**3.2.7.2 Environmental Damage (Region)**

In this category, consideration should be given to potential accidental pollutant emissions to air, including acid rain, groundwater, wastewater, and soil.

The environmental damage (local) due to the accidental release of the product to the environment criteria would include the following factors:

- Air quality issues; Six principal air pollutants (air quality standards)
  - Carbon Monoxide (CO)
  - Nitrogen Dioxide (NO₂)
  - Sulfur Dioxide (SO₂)
  - Lead (Pb)
  - Ground Level Ozone (O₃) (primary constituent of smog)
  - Particulate Matter
- Water quality issues; water pollution
- Acid rain
- TRI (Toxic Release Inventory) list issues

The most desirable products in this category would provide the greatest reduction in potential environmental damage (local) due to the accidental release of the product at GRC.

**Rating Guideline of Environmental Damage (Local)**

The qualitative measurement would be used to determine the potential environmental damage (local) benefits. It will determine if there are any of these issues presented in the products, compare the products against one another and rate them.

**Table 3.18: Rating guidelines for environmental damage (local)**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for environmental damage (local) benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>Limited</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>0</td>
<td>Product does not provide environmental damage (local) benefits</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided as follows:

For rating a product in the “adhesive removers” category, if the product contains the TRI list chemicals, 0 would be a rating for this product, since TRI list chemicals would post the potential danger to the environment.

### 3.2.7.3 Global Issues

There are several factors to be considered in relation to these global issues. They are;
• Ozone layer depletion
• Global warming/Greenhouse gases emissions
• Biodiversity

One of the targets in Executive Order 13148 was to phase out the procurement of Class 1 ozone-depleting substances from the Federal agency by the end of 2010. Therefore, the elimination of Class 1 ozone-depleting substances or chemicals would reduce the effect of ozone layer depletion.

For global warming issue, reducing the production of greenhouse gases to the environment would help with the issues with the global warming. The principal greenhouse gases that enter the atmosphere are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and fluorinated gases.

Biodiversity is often used as a measure of the health of biological systems. If there are many hazardous chemicals or pollutants presented in the environment, a decrease in the biodiversity or an increase in extinction may occur.

The most desirable products in this category would provide the greatest reduction in potential globally damaging effects due to the use of the product at GRC.

**Rating Guideline of Global Issues**

The qualitative measurement would be used to determine the potential for global issues benefits. Many sections of MSDS sheets of the products provide the information related to the issues of biodiversity, such as ecological information, toxicity to wildlife, and ecotoxicity. Use this information to help with rating the products.
Table 3.19: Rating guidelines for global issues

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for global issues benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>Limited</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>0</td>
<td>Product does not provide global issues benefits</td>
</tr>
</tbody>
</table>

### 3.2.8 Compliance

There are three main criteria in this assessment factor. They are the regulatory benefits, Executive Order (EO) and policy benefits, and liabilities benefits. The benefits will be based upon a relative comparison with the products that create the greatest compliance challenges, whether the issues are environmentally-related (such as EPA regulations) or health and safety (OSHA regulations).

#### 3.2.8.1 Regulatory Benefits

The most desirable products in this category would provide the greatest relief from federal and state regulatory requirements at GRC.

The most pertinent major federal environmental laws are The Clean Air Act, Clean Water Act, RCRA (for land), and CERCLA (for groundwater). Also, the Toxic Substances and Control Act (TSCA) is the primary Federal statue regulating the use of certain chemicals and substances, including asbestos, PCBs, radon, and lead. Also, OSHA requirements present a major reporting and compliance issues.

Not only must the products comply with federal regulations, but also compliance with state and local regulations need to be considered.
Other than the compliance with those regulations that have stated above, other considerations are the issues of record-keeping, monitoring, reporting, permits and time consuming that are involved with the compliances of the products.

**Rating Guideline of Regulatory Benefits**

The qualitative measurement would be used to determine the regulatory benefits. The MSDS sheets of the products in the section of regulatory information would provide the information of compliance related issues.

**Table 3.20: Rating guidelines for regulatory benefits**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for regulatory benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>Limited</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>0</td>
<td>Product does not provide regulatory benefits</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided as follows:

For rating a product in the “heavy-duty degreaser” category, if the product does not contain any chemicals that are listed in those regulations, 4 or 5 would be a rating for this product. Also, if a product contains the most percentage of the listed chemicals that are regulated by those regulations, 0 or 1 would be a rating for this product.
3.2.8.2 Executive Order (EO) and Policy Benefits

The most desirable products in this category would provide the greatest benefit regarding compliance with Executive Orders (EOs) and NASA policies; NASA Policy Directives (NPDs) and NASA Procedures and Guidelines (NPGs), at GRC, or in reducing compliance requirements.

There are several EOs and NPDs/NPGs that will be considered for product evaluation. The following are the examples of the EOs and NPDs/NPGs:

- NPG 8820.3 – P2
- NPG 8830.1 – Affirmative procurement plan – EPPs
- NPD 8820.3 – Facility sustainable design
- EO 12856 – Goals for eliminating or reducing use of toxic chemicals
- EO 12902 - Water conservation
- EO 12902 – Energy conservation
- EO 13101 – Waste prevention & recycling
- EO 13101 – Recycled products
- EO 13123 – Greenhouse gas reduction
- EO 13123 – Reduce petroleum products
- EO 13123 – Reduce water consumption
- EO 13123 – Reduce energy consumption
- EO 13123 – Reduce targets: persistence, bioaccumulations, toxic, TRI, ozone
Rating Guideline of Executive Order (EO) and Policy Benefits

The qualitative measurement would be used to determine the Executive Order (EO) and policy benefits.

Table 3.21: Rating guidelines for Executive Order (EO) and policy benefits

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for Executive Order (EO) and policy benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>Limited</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>0</td>
<td>Product does not provide EO &amp; policy benefits</td>
</tr>
</tbody>
</table>

3.2.8.3 Liability Reduction Benefits

The most desirable products in this category would provide the greatest reduction of potential liabilities related to product use and disposal at GRC. Consideration will be given for reducing liabilities, such as employee legal exposures or medical surveillance if using a chemical with limited exposure requirements, and disposing of hazardous waste related to potential superfund sites.

Rating Guideline of Liability Reduction Benefits

The qualitative measurement would be used to determine the liability reduction benefits.
Table 3.22: Rating guidelines for liability reduction benefits

<table>
<thead>
<tr>
<th>Rating</th>
<th>Potential for liability reduction benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>2</td>
<td>Limited</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>0</td>
<td>Product does not provide liability reduction benefits</td>
</tr>
</tbody>
</table>

An example of using this rating guideline is provided as follows:

For rating a product in the “heavy-duty degreaser” category, if the product contain pH in the neutral range (about 7), has the biobased components listed as the ingredients (more than 50% of the threshold requirement), and no requirement for environment and safety issue, 4 or 5 would be a rating for this product. Also, if a product is a very high acidic or basic and has been listed as potential hazardous or posted danger to environmental or safety issue, 0 or 1 would be a rating for this product.
4.1 Overview

The web-based application has been developed based on the EPP+ model evaluation process and product scoring system in the previous chapter. This web-based application was developed by combining ASP.NET, a programming framework for creating web applications, along with Microsoft Access as the database management system; C# (“C-sharp”). serves as the programming language supported by the .Net framework.

There are 3 layers (3-tier architecture) for this web-based application structure. The three tiers include the following:

- **Data Layer** – This database layer was developed by using Microsoft Access. At this layer, the data is stored, managed, organized, and retrieved whenever requested by the user.

- **Business Logic Layer** – This layer contains the business logic such as product score calculations, and is developed by using C#.
• Presentation Layer – This layer has web forms where the user inputs the values and scores of the products, which were developed by using ASP.NET. This web form allows the user to perform various types of functions like entering, deleting, updating, and viewing the data.

Figure 4.1 depicts this web-based application structure.

Figure 4.1 Web-based application structure
A user will be able to score a product by using the web forms in the presentation layer. There are four main web forms identified as criteria configuration, category configuration, product configuration, and product replacement. The details of these web forms are explained later.

For security and efficiency, the user cannot view or access the database directly. However, if the user tries to access the database directly, the application will not perform any calculations required to score the product. At that point, use or access of the database is merely not worth anything to the user. The user would use only the presentation layer.

After completing the construction of this web-based application, the method of multiple criteria decision making will be applied to those results and provide the measurement of the products’ sustainability.

4.2 EPP+ Web-Based Application Process

There were 2 main steps for constructing this EPP+ web-based application. These steps were:

- Analyze Required Specifications
- Design the structure

4.2.1 Analyze Required Specifications

At the beginning of this project, the information needed to construct the appropriate application related to the product scoring system had to be analyzed; the
scoring system was explained in the previous chapter. All the requirements for this project needed to be identified.

There are 2 main requirements for this project. They are as follows;

- General requirements
- Technical requirements

4.2.1.1 General Requirements

In the evaluation process or product scoring process, the EMO (Environmental Management Office) will have the persons who gather all of the product information rate each product individually, and then input all the scores of the products back into the spreadsheet. Each spreadsheet represents each product’s category. In the spreadsheet, the scores of products in each assessment factor will be displayed. This information in the spreadsheets will be kept in the EMO department. When other departments in the facilities want to get this information, they need to contact the EMO personnel by phone or email. This is the deficiency in the communication process; time is lost while waiting on the phone to obtain the information or waiting for email replies from both sides (other departments and EMO personnel). The inconvenience for assessing the information, since the information is only available in the spreadsheets (both in the forms of hard copy or computer software) which kept in the EMO department, they must assign the area for keeping this information (loss of space) and assign the personnel for obtaining the information (loss of labor time).
Therefore, in order to solve the above problems in the product scoring process, the general requirements for this new system must be set in the web-based application. This new system will perform the following:

- Support two types of users: Administrator and regular
  - Administrators are users who have an authorization for accessing the product scoring system, giving the weighting factors and rating or scoring of the products, monitoring the web-based application, and obtaining the replacement products.
  - Regular users are users who only obtain the replacement products.

- Allow administrators to add unlimited criteria, categories and products
  - In the future, the system may have more than 8 main assessment factors or criteria, more products that will be evaluated in this system and more categories that will be created.

- Allow both administrator and regular users to find the product replacement
  - This feature highlights the purpose of this system as it allows both administrator and regular users to find adequate replacement products within a specific product-use category. The logic of the score calculation will be addressed in this product replacement stage.
4.2.1.2 Technical Requirements

This requirement is related to the technical issue of the system. Basically, it is what the system is able to perform when it is completed.

First, this system can be accessed anywhere from any platform. Since this system is in the form of a web-based application, it can be access from any locations that has the Internet access. Also, this system is designed for all the platforms such as Windows, Mac, or Linux. This web-based application can be accessed thru different web surfers such as Internet Explorer, Firefox, Google Chrome, etc. This gives access to the system for a wide variety of users.

Second, this system will be easy to maintain. For example, if there are bugs or errors in the program, the manufacturer will provide an update by allowing the users to download the new fixes. If any users did not download or update the program, the problem will still be present in those users’ program. For this particular system, if there are any bugs or errors to be fixed, the administrator who maintains the system will fix and correct the problem. After fixing the errors, the administrator will update the current version to the web. Therefore, it is an easy way to maintain the system by not involving many users in this process. Previously, users would have had to contact the original analyst, if they were able to track them down in the first. This feature enables the user or the administrator the ability to correct problems more efficiently and effectively.

4.2.2 Design the Structure

There were four main steps in the design process which are;

- Create Use Cases
• Design the Database Structure
• Design the Business Logic Tier using C#
• Design the Presentation Tier

4.2.2.1 Create Use Cases

In the beginning of designing the system, the first step was to create the use cases. A use case is a description of a system’s behavior as it responds to a request that originates from outside of that system. In other words, a use case describes “who” can do “what” with the system in question.

In this system, we have two use cases which are regular user and administrator user. Since the general requirements stated that this system should support two types of users, it is obvious to have two use cases in the design process.

The first use case is the regular user. Figure 4.2 shows the functions of the regular user. The functions that the regular user can perform are finding replacement products and changing password. Finding replacements is a function that allows the user to locate the product replacement in the category that the user selected. Changing password is a function that allows the user to change the password for logging in to the system.
The second use case is the administrator user. Figure 4.3 shows the functions of administrator user. There are six main functions that the administrator user can perform: configure criteria, configure category, configure product, manage user, review log, and find replacements.
In each main function, there are sub-functions that allow administrator users to perform the work that relates to the main function. For example, when the administrator user uses the configure criteria function, the administrator user can edit the criteria.
information such as changing the criteria name or description. Also, the administrator user can add or delete the criteria in the system as they see fit.

The configure category function refers to the product-use category. The administrator user can edit the category information such as the name of the category, adding a new category or deleting a category. Also, the administrator user has the ability to change the weighting factor of the category. As mentioned in the previous chapter, each category will have its own weighting factors. Thus, allowing for change in the weighting factor would fulfill the goal for this function.

In the configure product function, the administrator user can edit the product information, or add or delete the product. Also, the administrator user has the ability to change the rating or score of the product.

In the manage user function, the administrator user can edit the user’s profile. The user’s profile contains the information of the user which is user name, first name, last name, type of user such as regular or administrator, and contact information such as email address, phone number, or organization. Also, the administrator user has the ability to send the password for the users (both regular and administrator type) that are in this system. Adding or deleting users can be performed in this manage user function.

In the review log function, the administrator user can monitor the activities of the system such as who is using the system, when the user is using the system, and what product in which category for which users are searching for product replacements.

The find replacement function allows the administrator user to find the product replacement in the category that the administrator user selected. It is the same function as
used in the regular user’s find replacement. This is the only function that the administrator and regular user can both use

4.2.2.2 Design Database Structure

The data tier called the database was developed using Microsoft Access. In designing the database one of the important things that was to be clearly identified was how the data are related to each other. The data are grouped into related fields and each group of fields is represented by tables, such as which tables are related in a one-to-many relationship (e.g. one product-use category will have the multiple products) and what is a many-to-many relationship (e.g., many products can related to many criteria or assessment factors).

One of the most important steps in designing a database is to make sure that the data is properly distributed among its tables, and this distribution is called database normalization. Normalization can be explained with a very deep and broad outlook, but efforts have been made to explain it in a simple way and pertain it to the scope of work for developing this web-based application. The important factors considered are as follows:

• Use of key field

The key field in a table is used to define uniqueness that is used by other tables to relate to the fields. For example, the category and product tables have a unique ID (identification) through which they are related to each other and with their further tables. A key field should have the following characteristics for efficiency: it should be only one field and should be numeric, such as the
autonumber that is generated automatically by the Microsoft Access. It should not change automatically such as with a social security number. Any change in that number makes it difficult to search for records and their relationships. For better security for the key field, it should be hidden from the user.

- The unique information is stored in one place

Data that is the identical or related is stored in a specific place and referred to with an ID when a reference to it is needed. If some information is changed, it can be changed in one place and the information will change subsequently through the whole application. For example, the category table has a unique ID field (autonumber field) that is its key field, and the product and the weighting factor tables use it to refer to the category. Therefore, a category table, rather than storing all the products and weighting factors information, would simply refer to the product ID and weighting factors ID, which are related to category ID.

In this database, the 2 components for the product evaluation are the product-use category (or the “Access” category-designated) and the product.

Category is considered to be the main parent. The product belongs to a category and so it is called its child. A product cannot exist without a defined category. Figure 4.4 explains the category and product relationship.
Initially, there are eight (8) assessment factors or criteria for which a product will be evaluated or scored. A product cannot be scored without a category because the weighting factors for the criteria are at the category level and they are applied to the products. Also, the weighting factors remain the same for the same category, and so all the products that belong to this category will use the same weighting factors for the calculation of the products’ scores. Figure 4.5 shows the relationship of the initial assessment factors or criteria in the database.

After establishing the relationship between the components in the database, the database tables of this web-based application will be created. The most common relationship that is used in this database table is one (1) to many (\(\infty\)) relationship type. For example, one product-use category can have more than one product and one product can have more than one value for evaluating factors. These tables are connected to each other using the unique ID that is explained in the above section. Figure 4.6 shows the screen view of the list of tables by Microsoft Access and Figure 4.7 presents the database diagram for this EPP+ program.
Figure 4.5 Criteria diagram
Figure 4.6 Table in the Database viewed by Microsoft Access
According to Figure 4.7, the database of EPP+ program consists of 6 main tables which contain all the relative data for using in this web-based application development. There are tables of Category, Criteria, WeightFactor, ProductScore, Product, and UsageLog. These 6 tables are described as the following:

- **Criteria Table**

  This table stores the information for the Criteria. This EPP+ program can add the unlimited Criteria to it. Table 4.1 shows the detail information that is stored in the Criteria table.
Table 4.1: The Criteria table

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data Type</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>CriteriaID</td>
<td>AutoNumber</td>
<td>Unique Identification</td>
</tr>
<tr>
<td>CriteriaName</td>
<td>Text</td>
<td>Alphanumeric (both alphabet and number)</td>
</tr>
<tr>
<td>ParentCriteriaID</td>
<td>Number (Integer)</td>
<td>ID of the parent criteria of this criteria. 0 for root criteria</td>
</tr>
<tr>
<td>CriteriaDescription</td>
<td>Memo (Long Text)</td>
<td>The description of the criteria. It will be displayed to end user inside the popup on the Product Replacement screen</td>
</tr>
</tbody>
</table>

In this table, having the ParentCriteriaID field allows us to have the parent-child relationship between criteria. Figure 4.8 shows the sample of the relationship of the parent-child criteria of Affirmative Procurement.

![Diagram of Parent-Child Relationship in Affirmative Procurement](figure.png)

Figure 4.8 Parent-Child Relationship in Affirmative Procurement

From Figure 4.8, the biobased content and the recycled content are the child of the Affirmative Procurement. As it showed by both biobased and
recycled content has the same parent (ParentCriteriaID = 1) which mean its parent is Affirmative Procurement (CriteriaID = 1).

- **Category (Product-use category) Table**

  This table stores the category of Product-use. This EPP+ program can add the unlimited Category to it. Table 4.2 shows the detail information that is stored in the Category table.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data Type</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>CategoryID</td>
<td>AutoNumber</td>
<td>Unique Identification</td>
</tr>
<tr>
<td>CategoryName</td>
<td>Text</td>
<td>Alphanumeric (both alphabet and number)</td>
</tr>
</tbody>
</table>

- **Product Table**

  This table stores the information of Product. This EPP+ program can add unlimited Products to it. Table 4.3 shows the detail information that is stored in the Product table.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data Type</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProductID</td>
<td>AutoNumber</td>
<td>Unique Identification</td>
</tr>
<tr>
<td>ProductName</td>
<td>Text</td>
<td>Alphanumeric (both alphabet and number)</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Text</td>
<td>Product's manufacturer</td>
</tr>
<tr>
<td>CategoryID</td>
<td>Number (Integer)</td>
<td>ID of the category that this product is belongs to</td>
</tr>
<tr>
<td>ProductWebsite</td>
<td>Text</td>
<td>Website that have this product</td>
</tr>
<tr>
<td>ProductPrice</td>
<td>Text</td>
<td>Price of the product. Ex. $50 per 24 Oz. or $1000 per 55-gallon drum</td>
</tr>
</tbody>
</table>
In this table, there is another parent-child relationship between the Product and the Category that the Product belongs to. Figure 4.9 shows a sample of the relationship of the parent-child between Category and Product.

![Figure 4.9 Parent-Child Relationship of the product and category](image)

From Figure 4.9, N-methyl pyrrolidone and Bioact 113 are the children of Heavy Duty Solvents (Cleaners)/ Degreasers (CategoryID =13). Both products have the same CategoryID which is 13, which belong to the same Product-use category that showed the same CategoryID = 13.

- **WeightFactor Table**

  This table stores the weighting factors of each product’s category on each criteria. This EPP+ program can add the unlimited WeightFactor based on the number of the Category and Criteria. Table 4.4 shows the detail information that store in the WeightFactor table and Table 4.5 shows an example of using the WeightFactor table.
### Table 4.4: The WeightFactor Table

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data Type</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>WeightFactorID</td>
<td>AutoNumber</td>
<td>Unique Identification</td>
</tr>
<tr>
<td>CategoryID</td>
<td>Number (Integer)</td>
<td>ID of the category</td>
</tr>
<tr>
<td>CriteriaID</td>
<td>Number (Integer)</td>
<td>ID of the criteria</td>
</tr>
<tr>
<td>Weight</td>
<td>Number (Decimal)</td>
<td>Weighting Factor of the given category on the given criteria. The value should be between 0 and 1</td>
</tr>
</tbody>
</table>

### Table 4.5: Example of using the WeightFactor Table

<table>
<thead>
<tr>
<th>CategoryID</th>
<th>CriteriaID</th>
<th>Weight</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>102</td>
<td>1.0</td>
<td>Weighting factor of &quot;Heavy Duty Solvents (Cleaners)/Degreasers&quot; category for &quot;Biobased Content&quot; criteria is 1.0</td>
</tr>
<tr>
<td>13</td>
<td>145</td>
<td>0.0</td>
<td>Weighting factor of &quot;Heavy Duty Solvents (Cleaners)/Degreasers&quot; category for &quot;Recycled Content&quot; criteria is 0.0</td>
</tr>
</tbody>
</table>

Where CategoryID =13 is “Heavy Duty Solvents (Cleaners)/Degreasers” category  
CriteriaID =102 is “Biobased Content” criteria  
CriteriaID = 145 is “Recycled Content” criteria

- **ProductScore Table**

  This table stores the score of each Product on each Criteria. This EPP+ program can add the unlimited ProductScore based on the number of the Product and Criteria. Table 4.6 shows the detail information that store in the ProductScore table and Table 4.7 shows an example of using the ProductScore table.
Table 4.6: The ProductScore Table

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data Type</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProductScore</td>
<td>AutoNumber</td>
<td>Unique Identification</td>
</tr>
<tr>
<td>ProductID</td>
<td>Number (Integer)</td>
<td>ID of the product</td>
</tr>
<tr>
<td>CriteriaID</td>
<td>Number (Integer)</td>
<td>ID of the criteria</td>
</tr>
<tr>
<td>Score</td>
<td>Number (Decimal)</td>
<td>Score of the given category on the given criteria. The value should be between 0 and 5</td>
</tr>
</tbody>
</table>

Table 4.7: Example of using the ProductScore Table

<table>
<thead>
<tr>
<th>ProductID</th>
<th>CriteriaID</th>
<th>Score</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>102</td>
<td>2.0</td>
<td>Score of &quot;N-Methyl Pyrrolidone&quot; product in &quot;Biobased Content&quot; criteria is 2.0</td>
</tr>
<tr>
<td>24</td>
<td>145</td>
<td>3.5</td>
<td>Score of &quot;Bioact 113&quot; product in &quot;Recycled Content&quot; criteria is 3.5</td>
</tr>
</tbody>
</table>

Where ProductID = 22 is “N-methyl pyrrolidone” product
ProductID = 24 is “Bioact 113” product
CriteriaID = 102 is “Biobased Content” criteria
CriteriaID = 145 is “Recycled Content” criteria

- UsageLog Table

This table stores logging information, such as username or when the EPP+ program has been used. This information can be used for various statistical analyses, such as who has updated the system, dates the system was accessed or updated, etc. These statistics can also be used for improvement of the system.

Table 4.8 shows the detail information that is stored in the UsageLog table.
Table 4.8: Example of using the UsageLog Table

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data Type</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>UsageLogID</td>
<td>AutoNumber</td>
<td>Unique Identification</td>
</tr>
<tr>
<td>UserName</td>
<td>Text</td>
<td>User who accessed replacement screen</td>
</tr>
<tr>
<td>UsageTime</td>
<td>Date/Time</td>
<td>Time using replacement screen</td>
</tr>
<tr>
<td>ProductName</td>
<td>Text</td>
<td>Product name that users designated to find the replacement</td>
</tr>
<tr>
<td>CategoryID</td>
<td>Number (Integer)</td>
<td>ID of the selected category</td>
</tr>
</tbody>
</table>

4.2.2.3 Design the Business Logic Tier Using C#

The business layer is the layer that contains the business logic, for example the logic to calculate the score of the products. It is a middle layer that connects the data layer and the presentation layer together. For this program, it has been developed using C# language which was created in Visual Studio 2008.

Normally, the business logic tier is started by creating the use cases first, and then designing and implementing C# classes according to the use cases.

Once the use cases have been created, C# classes should be designed and implemented according to the use cases. In the C# classes, there will be properties and methods. Properties represent the class’s attributes while methods represent the class’s behaviors. Figure 4.10 presents the C# classes for this web-based application. Note that the class’s properties are similar with the database fields in underlying the database table while the class’s methods are corresponding to the use case. For example, the Product class has properties which are ProductID, ProductName, CategoryID, etc., which are
similar to fields of Product Table. The Product class has methods which are LoadProduct, SaveProduct, etc. which correspond to the Configure Product in the use case.

Figure 4.10 C# Classes in EPP+ Program

According to Figure 4.10, the C# Classes in EPP+ program consists of 4 main classes which are Product, Category, Criteria, and User. These 4 classes are described as the following:

- Product Class

Table 4.9 and 4.10 describes the properties and methods for this Product class, respectively.
Table 4.9: Properties in Product Class

<table>
<thead>
<tr>
<th>Property Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProductID</td>
<td>Number (Integer)</td>
<td>Unique Identification</td>
</tr>
<tr>
<td>ProductName</td>
<td>Text</td>
<td>Product name.</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Text</td>
<td>Product’s manufacturer</td>
</tr>
<tr>
<td>CategoryID</td>
<td>Number (Integer)</td>
<td>ID of the category that this product belongs to.</td>
</tr>
<tr>
<td>ProductWebsite</td>
<td>Text</td>
<td>Website having product information.</td>
</tr>
<tr>
<td>ProductPrice</td>
<td>Text</td>
<td>Formatted product’s price. For example, $50 per bottle or $900.00 per 55-gallon drum.</td>
</tr>
</tbody>
</table>

Table 4.10: Methods in Product Class

<table>
<thead>
<tr>
<th>Method Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LoadProduct</td>
<td>Load product information from database</td>
</tr>
<tr>
<td>SaveProduct</td>
<td>Save product information to database</td>
</tr>
<tr>
<td>DeleteProduct</td>
<td>Delete a given product from database</td>
</tr>
<tr>
<td>LoadScore</td>
<td>Load scores of the given product on each criteria</td>
</tr>
<tr>
<td>SaveScore</td>
<td>Save scores of the given product on each criteria</td>
</tr>
</tbody>
</table>

- Category Class

Table 4.11 and 4.12 describes the properties and methods for this Product class, respectively.

Table 4.11: Properties in Category Class

<table>
<thead>
<tr>
<th>Property Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CategoryID</td>
<td>Number (Integer)</td>
<td>Unique Identification</td>
</tr>
<tr>
<td>CategoryName</td>
<td>Text</td>
<td>Category name.</td>
</tr>
</tbody>
</table>
Table 4.12: Methods in Category Class

<table>
<thead>
<tr>
<th>Method Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LoadCategory</td>
<td>Load category information from database</td>
</tr>
<tr>
<td>SaveCategory</td>
<td>Save category information to database</td>
</tr>
<tr>
<td>DeleteCategory</td>
<td>Delete a given category from database</td>
</tr>
<tr>
<td>LoadWeightFactor</td>
<td>Load weighting factors of the given category on each criteria</td>
</tr>
<tr>
<td>SaveWeightFactor</td>
<td>Save weighting factors of the given category on each criteria</td>
</tr>
</tbody>
</table>

- Criteria Class

Table 4.13 and 4.14 describes the properties and methods for this Product class, respectively.

Table 4.13: Properties in Criteria Class

<table>
<thead>
<tr>
<th>Property Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CriteriaID</td>
<td>Number (Integer)</td>
<td>Unique Identification</td>
</tr>
<tr>
<td>CriteriaName</td>
<td>Text</td>
<td>Criteria name.</td>
</tr>
<tr>
<td>CriteriaDescription</td>
<td>Text</td>
<td>The description of the criteria. It will be displayed to end user inside the popup on the Product Replacement screen.</td>
</tr>
<tr>
<td>ParentCriteriaID</td>
<td>Number (Integer)</td>
<td>ID of the parent criteria of this criteria. 0 for root criteria.</td>
</tr>
</tbody>
</table>

Table 4.14: Methods in Criteria Class

<table>
<thead>
<tr>
<th>Method Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LoadCriteria</td>
<td>Load criteria information from database</td>
</tr>
<tr>
<td>SaveCriteria</td>
<td>Save criteria information to database</td>
</tr>
<tr>
<td>DeleteCriteria</td>
<td>Delete a given criteria from database</td>
</tr>
</tbody>
</table>
After constructing the C# classes for this business logic tier, the writing for the source codes for this web-based application will be done by using Visual Studio software.

Figure 4.11 shows a part of the source code that displayed in Visual Studio.

![C# by Visual Studio](image)

**Figure 4.11 C# by Visual Studio**

In this Figure, the file extension of source code of C# will have an extension ending with .cs. Usually, there is one C# file corresponding with one screen.

The calculation algorithm of this scoring system will be created in this business logic tier. Figure 4.12 presents the logic for calculating the score in the system.
Figure 4.12 Scoring Flow Chart in EPP+ program
4.2.2.4 Design the Presentation Tier

The presentation tier consists of web forms where the user inputs the weighting and scores of the products. These web forms allow the user to perform various types of functions such as, entering, deleting, updating, and viewing the data. The user can make changes to the criteria, category, and product using the presentation tier.

The presentation tier is connected to the data tier (database) through the business logic tier, so that relationships among the tables and the data input by user are correlated with the logic and relationships required to evaluate the product.

The web application starts with a login form as shown in Figure 4.13. Once the user login to use this program, the user will get to the main screen which is dynamically based on type of user. If the user is an administrator, his application will be able to perform the full functionality as shown in Figure 4.14. If the user is a regular user, he will be only to use the product replacement function as shown in Figure 4.15.

![Figure 4.13 Main screen of EPP+ web-based application program](image)
Figure 4.14 Administrator User Screen

Figure 4.15 Regular User Screen
4.3  **EPP+ Web-Based Application Functionality**

The EPP+ web-based application has been finished in the development process. At the present time, this application is deployed on a private network server. To access this application, the users need to request permission to use this program. The web-based application is located at [http://www.eppplusproject.com](http://www.eppplusproject.com).

As the administrator user, this type of user can gain all of the full functionalities of this application. There are 5 main functionalities that can be performed in this EPP+ program. They are Criteria Configuration, Product Management: Category and Product Configuration, User Management, Usage Log, and Product Replacement. They are described as the following:

4.3.1  **Criteria Configuration**

In the criteria configuration part, the user can perform add, edit, or delete the criteria in the system. Also, the criteria are built as hierarchically listings. Thus, in each main criteria, they can have many sub-criteria or parameters that related to that criteria. The Criteria Configuration is located in the main tool bar indicated as “Criteria”. Figure 4.16 shows the criteria configuration screen with some of the criteria that will be used in the evaluation process.
When adding or editing the criteria in the system, the user can write the description of that criteria into the system. At the present time, only the main criteria’ descriptions will be displayed on the Product Replacement screen. Figure 4.17 shows the criteria setup dialog box appears when the user edits or adds the criteria into the system.
Figure 4.17 Criteria Setup Dialog Box

To delete the existing criteria in this Criteria Configuration, the user must select the criteria that they want to delete and click at the delete icon, which is located in the Criteria toolbar. At this point, the system will send the warning message which appears as shown in Figure 4.18 for verifying this process. When the user deletes the main criteria, the sub-criteria or the parameters that related to that criteria also will be deleted.

Figure 4.18 Deleting Message in Criteria Configuration
4.3.2 Product Management

The Product Management consists of 2 key functionalities in this program, which are Category Configuration and Product Configuration. The Category Configuration is located on the left panel and the Product Configuration is located on the right panel of the screen. Figure 4.19 shows the Product Management screen with the Category and Product Configuration.

![Figure 4.19 Product Management](image)

In the Product Management section, it allows the user to perform add/delete/update/edit functions for both the product-use category and the product itself. The parent-child relationship also shows in this Product Management section. If the
product-use category has been deleted, all its products in that category will be deleted too.

The user will be able to insert the weighting factors of the criteria of the product-use category in this Category Configuration. Figure 4.20 shows the weighting factors of the heavy duty solvents (cleaners)/degreasers on the Category Setup screen, which is used for inserting the name of the product-use category and the weighting factors of that category.

![Figure 4.20 Category Setup in the Category Configuration](image_url)
After the product-use category has been created, the user will be able to insert the information of the product on the Product Configuration part. The score of the product will be inserted in this part. Figure 4.21 shows the product setup screen where the information of the product including the product’s score, can be inserted into this Product Configuration section.

**Figure 4.21 Product Setup in the Product Configuration**
4.3.3 User Management

The information of the users, both administrator and regular, who use this program will be kept in this part. Figure 4.22 shows the information of the users who are already in the User Management record, and Figure 4.23 shows the user setup screen when adding a new user or editing the existing user in the User Management section.

![User Management Table]

Figure 4.22 User Management
**Figure 4.23 User Setup**

<table>
<thead>
<tr>
<th><em>User Name:</em></th>
<th>yankyyod</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>First Name:</em></td>
<td>Amarin</td>
</tr>
<tr>
<td><em>Last Name:</em></td>
<td>Kongfawerent</td>
</tr>
<tr>
<td><em>Email:</em></td>
<td><a href="mailto:yankyyod@hotmail.com">yankyyod@hotmail.com</a></td>
</tr>
<tr>
<td><em>Password:</em></td>
<td>***</td>
</tr>
<tr>
<td><em>Confirm Password:</em></td>
<td>***</td>
</tr>
<tr>
<td>Organization:</td>
<td>CSU</td>
</tr>
<tr>
<td>Phone Number:</td>
<td>(216)771-6462</td>
</tr>
<tr>
<td>Status:</td>
<td>Active</td>
</tr>
<tr>
<td>Roles:</td>
<td>Administrator, User</td>
</tr>
</tbody>
</table>

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4.3.4 Usage Log

This is where the administrator user can monitor the activities of the system such as who is using the system, what product in which product-use category for which users are searching replacement. Figure 4.24 shows the information that display in the Usage Log screen.

![Figure 4.24 Usage Log](image-url)
4.3.5 Product Replacement

This is the only functionality of this program that both administration and regular user can access. This functionality will be used for determining the replacement product or the product that has already been evaluated. The scores of the products that have been evaluated based on the criteria will be displayed in this section. Figure 4.25 shows the Product Replacement screen when the users use this functionality and Figure 4.26 shows an example of the result when using this application.

![Figure 4.25 Product Replacement](image-url)
Figure 4.26 Results of the Product Replacement

<table>
<thead>
<tr>
<th>Product</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limonene</td>
<td>9.00</td>
<td>10.00</td>
<td>5.00</td>
<td>5.00</td>
<td>4.00</td>
<td>0.00</td>
<td>0.00</td>
<td>8.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Vortex</td>
<td>4.56</td>
<td>5.36</td>
<td>7.20</td>
<td>7.20</td>
<td>5.84</td>
<td>7.20</td>
<td>4.56</td>
<td>4.56</td>
<td>3.76</td>
<td>3.20</td>
</tr>
<tr>
<td>Simple Green cleaner/deg</td>
<td>5.55</td>
<td>3.00</td>
<td>3.90</td>
<td>3.90</td>
<td>4.05</td>
<td>3.00</td>
<td>5.70</td>
<td>4.05</td>
<td>5.85</td>
<td>4.65</td>
</tr>
<tr>
<td>Crystal Simple Sirn Clean/deg</td>
<td>7.84</td>
<td>9.60</td>
<td>6.56</td>
<td>6.56</td>
<td>7.20</td>
<td>6.40</td>
<td>5.60</td>
<td>6.72</td>
<td>5.60</td>
<td>6.24</td>
</tr>
<tr>
<td>T-Pole Plus Concentrate</td>
<td>6.90</td>
<td>6.82</td>
<td>8.64</td>
<td>8.64</td>
<td>9.74</td>
<td>8.64</td>
<td>6.91</td>
<td>6.01</td>
<td>6.27</td>
<td>5.07</td>
</tr>
<tr>
<td>Bioact 113</td>
<td>10.00</td>
<td>7.86</td>
<td>10.00</td>
<td>10.00</td>
<td>9.71</td>
<td>9.43</td>
<td>10.14</td>
<td>6.71</td>
<td>9.71</td>
<td>9.00</td>
</tr>
<tr>
<td>Envir. Pref. Solvent</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
<td>7.20</td>
<td>7.07</td>
<td>7.07</td>
<td>6.00</td>
<td>5.73</td>
<td>5.73</td>
</tr>
<tr>
<td>N-methyl pyrrolidone</td>
<td>56.34</td>
<td>55.14</td>
<td>54.37</td>
<td>54.37</td>
<td>50.14</td>
<td>45.03</td>
<td>44.91</td>
<td>44.79</td>
<td>42.53</td>
<td>39.90</td>
</tr>
<tr>
<td>Product Price</td>
<td>$280.00 per 55-gallon drum</td>
<td>$900.00 per 55-gallon drum</td>
<td>$283.00 per 55-gallon drum</td>
<td>$283.00 per 55-gallon drum</td>
<td>$1760.00 per 55-gallon drum</td>
<td>$2700.00 per 55-gallon drum</td>
<td>$6000.00 per 55-gallon drum</td>
<td>$9600.00 per 55-gallon drum</td>
<td>$9000.00 per 55-gallon drum</td>
<td>$7300.00 per 55-gallon drum</td>
</tr>
</tbody>
</table>
CHAPTER V
TEST CASE OF EPP+ PROGRAM

5.1 Test Case Description

A test case for evaluating the product in the EPP+ program with a new web-based application tool will be presented in this chapter. This test case has been conducted based on the information acquired from GRC and the product manufacturers. The heavy-duty degreaser, which is in the product-use category of cleaners, will be the test case due to the high amount of usage of this product-use category at GRC. Also, these products contain some toxic or hazardous chemicals that are required to be reduced or eliminated from the site. The original heavy-duty degreaser products have been used at the site contain a restricted chemical, which is methylene chloride. Methylene chloride is a toxic and hazardous chemical which is listed under:

- the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA),
- Toxic Release Inventory (TRI) program under Title 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA), also known as
Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA)

- the Resource Conservation and Recovery Act (RCRA)

Since this chemical is a toxic and hazardous to the workers and the environment, there is a need to find the new product to replace this chemical.

In this test case, there are 10 replacement products in the heavy-duty degreasers product category to be reviewed and evaluated. These 10 replacement products are selected from the product catalog of the General Service Administration (GSA), which provides a wide range of products and services available to the federal government, and the product catalog of the Comprehensive Procurement Guidelines (CPG) program. Table 5.1 shows the 10 replacement products that will be used in this test case.

### Table 5.1: Information of 10 replacement products

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>Petroferm Inc.</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>Sherwin Williams Chem.</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>Sunshine Makers, Inc.</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>Florida Chemical Co. Inc.</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>Supreme Chemicals</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>Lyondell</td>
</tr>
<tr>
<td>New II</td>
<td>Ecolink Inc.</td>
</tr>
<tr>
<td>QED</td>
<td>Ecolink Inc.</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>Sunshine Makers, Inc.</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>Ecolink Inc.</td>
</tr>
</tbody>
</table>

These 10 replacement products will be reviewed and evaluated by the EPP+ program using its scoring system. The final score of these 10 replacement products will
be input into the worksheet. Then, the web-based application tool will be used to calculate a score using the scoring system, which will perform multiple-criteria decision making and determine of product’s measure of sustainability.

5.2 EPP+ Program Without Using the Web-Based Application Tool

5.2.1 Determine the requirements for a product replacement

The first step to evaluate the products is determining the important requirements for a product replacement. The requirement for these products, in this case, would be heavy-duty degreaser cleaner, and should have the following qualities:

- The product should not be regulated in the list of hazardous materials, such as listed in CERCLA, RCRA, etc.
- The product should contain no ozone-depleting compounds.
- The product should contain no substances classified as known or likely human carcinogens or reproductive toxicants.
- The product should preferably contain biobased ingredients.
- The product should not contain the substances with high corrosive reactions.
- The product should not contain the substances that are strongly irritating to humans.
- The product should be biodegradable.
- The product should have low VOC content.
- The product should have low toxicity in aquatic species such as fish.
- The product should have low flammability.
5.2.2 Determine the test products information

MSDS or TDS of test products should be reviewed. An MSDS provides a variety of important information, such as CASRN (chemicals in the products), physical data, toxicity, health effects, etc. If the MSDS still does not provide adequate information, a request for more information on products from manufacturers should be obtained. These 10 MSDS of test products are provided in the Appendix A of this dissertation.

Determining whether these test products contain any chemicals that are in the lists of the environmental regulations such as CERCLA, RCRA, EPCRA, and TRI, is a very important step. Since the EPP+ program is focused on reducing or eliminating hazardous materials, the chemicals listed in those regulations may jeopardize improving purchases of environmentally friendly products. In this test case, one of the test products is shown in the TRI list. Table 5.2 shows the chemicals in the test products related to environmental regulations.
Table 5.2: The regulations with these 10 test product chemicals

<table>
<thead>
<tr>
<th>Product</th>
<th>CASRN</th>
<th>Chemical Name</th>
<th>% Content</th>
<th>CERCLA</th>
<th>RCRA</th>
<th>EPCRA</th>
<th>TRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>5989-27-5</td>
<td>d-limonene</td>
<td>25-45</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>57018-52-7</td>
<td>1-T-Butoxy-2-Propanol</td>
<td>55-75</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>5989-27-5</td>
<td>d-limonene</td>
<td>73</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>111-76-2</td>
<td>2-butoxyethanol</td>
<td>&lt; 6</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>94266-47-4</td>
<td>d-limonene-Tech.</td>
<td>&gt; 93</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>111-76-2</td>
<td>2-Butoxyethanol</td>
<td>&lt; 8</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>141-43-5</td>
<td>Ethanol, 2-Amino</td>
<td>&lt; 4</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>1310-58-3</td>
<td>Potassium Hydroxide</td>
<td>&lt; 2</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>872-50-4</td>
<td>N-Methyl-2-pyrrolidone</td>
<td>&lt;=99.9</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>New II</td>
<td>64742-48-9</td>
<td>Isoparaffinic Hydrocarbon</td>
<td>N/A</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>QED</td>
<td>64475-85-0</td>
<td>Mineral Spirits</td>
<td>&gt; 80</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>111-76-2</td>
<td>2-butoxyethanol</td>
<td>&lt; 6</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>68647-72-3</td>
<td>Citrus Terpene</td>
<td>95</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>9016-45-9</td>
<td>Nonylphenoxy Polyethoxyethanol</td>
<td>5</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

5.2.3 **Determine the weighting factor of each assessment factors**

The weighting factors will be initially decided by the GRC P2 (Pollution Prevention) team and given each scoring assessment factor or criteria based on product-use category type. The value of the weighting factors will vary between 0 and 1. These weighting factors represent the relative importance of each assessment factor or criteria. For example, for a critical aerospace related product, all the weighting factors under the performance assessment factors may be 1.0, and other factors might be reduced to reflect
those priorities. Or for a heavy-duty cleaner product, the weighting factor under the health, safety, environmental issues and price may be given high factor values, and performance factors might be reduced. The assignment of the weighting factor to the test products is a very important step. These weighting factors need to be approved by EMO. In this test case, heavy duty degreaser, the weighting factor of all assessment factors for these test products was given by EMO for evaluating this product-use category. Table 5.3 shows the weighting factor of each assessment factors.
Table 5.3: Weighting factor of each assessment factors for the test products

<table>
<thead>
<tr>
<th>Assessment factors</th>
<th>Weighting factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Affirmative Procurement</strong></td>
<td></td>
</tr>
<tr>
<td>Recycled Content</td>
<td>1.0</td>
</tr>
<tr>
<td>Biobased Content</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td></td>
</tr>
<tr>
<td>Applicability</td>
<td>0.6</td>
</tr>
<tr>
<td>Performance Record</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td></td>
</tr>
<tr>
<td>Capital Costs</td>
<td>0.8</td>
</tr>
<tr>
<td>Operation &amp; Maintenance Costs (O&amp;M)</td>
<td>0.8</td>
</tr>
<tr>
<td>Payback Period</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Meeting Goals</strong></td>
<td></td>
</tr>
<tr>
<td>Recycle Potential</td>
<td>1.0</td>
</tr>
<tr>
<td>Solid Waste Minimization</td>
<td>1.0</td>
</tr>
<tr>
<td>Hazardous Waste Minimization</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Conservation</strong></td>
<td></td>
</tr>
<tr>
<td>Water Use Reduction</td>
<td>0.6</td>
</tr>
<tr>
<td>Energy Use Reduction</td>
<td>0.6</td>
</tr>
<tr>
<td>Other Resource Reduction</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Facility Environmental, Health, and Safety (EHS)</strong></td>
<td></td>
</tr>
<tr>
<td>Environmental Emissions</td>
<td>0.8</td>
</tr>
<tr>
<td>Health Risk Benefits</td>
<td>0.8</td>
</tr>
<tr>
<td>Safety Harzard Benefits</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Environmental Impact Potential</strong></td>
<td></td>
</tr>
<tr>
<td>Bioaccumulation</td>
<td>0.8</td>
</tr>
<tr>
<td>Environmental Damage</td>
<td>0.8</td>
</tr>
<tr>
<td>Global Issues</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Compliance</strong></td>
<td></td>
</tr>
<tr>
<td>Regulatory Benefits</td>
<td>0.8</td>
</tr>
<tr>
<td>Executive Order (EO) &amp; Policy Benefits</td>
<td>0.8</td>
</tr>
<tr>
<td>Reduction of Liabilities</td>
<td>0.8</td>
</tr>
</tbody>
</table>
5.2.4 Determine the score of the test products

After the weighting factor has been assigned to each assessment factor of the test products, the calculation of the score for each assessment factor will be performed. The rating score will be calculated based on the product rating guidelines described in chapter 3 of this dissertation.

5.2.4.1 Determine the score of recycle content

At the present time, recycled content in this product-use category has not been set by any government or other organizations yet. Therefore, 0 percent of recycled content will be set as a threshold for this type of product-use category. The recycled content of the product does not mean only the product itself. The packaging of the product also will be considered in this evaluation. Table 5.4 presents the rating guideline for recycled content of the test product and Table 5.5 presents the score of the recycle content (0 percent is a threshold) of the test products.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Contains the following % or threshold recycled content for product category</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Above 50% of recycled contents</td>
</tr>
<tr>
<td>4</td>
<td>Above 25% and up to 50% of recycled contents</td>
</tr>
<tr>
<td>3</td>
<td>Above AP threshold value and up to 25% of recycled contents</td>
</tr>
<tr>
<td>2</td>
<td>Equal AP threshold (0 %) of recycled content</td>
</tr>
<tr>
<td>1</td>
<td>Below AP threshold value of recycled content</td>
</tr>
<tr>
<td>0</td>
<td>Product does not contain recycled or reclaimed materials</td>
</tr>
</tbody>
</table>
Table 5.5: The score of test products with 0 percent recycled content as a threshold

<table>
<thead>
<tr>
<th>Product</th>
<th>Recycled Content Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>4</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>5</td>
</tr>
<tr>
<td>Crystal Simple Green®</td>
<td>2</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>5</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>2</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>2</td>
</tr>
<tr>
<td>New II</td>
<td>2</td>
</tr>
<tr>
<td>QED</td>
<td>2</td>
</tr>
<tr>
<td>Simple Green®</td>
<td>2</td>
</tr>
<tr>
<td>Vortex®</td>
<td>5</td>
</tr>
</tbody>
</table>

Since 0 percent is a threshold for this recycled content, the test products that do not contain any recycled content will automatically receive a score of 2, as referred in Table 5.4. Bioact 113, Cello The Natural D-Limonene, d-Limonene, and Vortex® have the similar chemical components, which is d-limonene or citrus terpene compounds. These chemical compounds are from the extraction of citrus skins or rinds. Since the citrus rinds are the products left over from the orange juice manufacturing process, it can be considered as a recycled product. The percentage of these chemical compounds can be presented as the percentage of the recycle content of the test product. The percentage of these chemical compounds in Bioact 113, Cello The Natural D-Limonene, d-Limonene, and Vortex® are 25-45%, >73%, >93%, and 95%, respectively. When compared to Table 5.4, the test products that have more than 50% of recycled content threshold will get the score of 5. The Bioact 113 which has a recycled content between 25 to 45 percent will get a score of 4. For the packaging of these test products, all of them do not have recycled content in the packaging. Crystal Simple Green® and Simple Green® are using plastic drums and the rest are using steel drums.
5.2.4.2 Determine the score of biobased content

34 percent of biobased content is a minimum threshold for the product in the grease remover category, according to the 2008 U.S. Department of Agriculture’s Designation of Biobased Items for Federal Procurement. The ASTM International Radioisotope Standard Method D 6866 is using for determining the biobased content. The biobased content of these test products are assumed and listed in Table 5.6. Table 5.7 presents the rating guideline for biobased content of the test product and Table 5.8 presents the score of the biobased content (34 percent is a threshold) of the test products.

Table 5.6: The biobased content of test product (assumption)

<table>
<thead>
<tr>
<th>Product</th>
<th>Biobased Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>100</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>100</td>
</tr>
<tr>
<td>Crystal Simple Green®</td>
<td>20</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>100</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>0</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>0</td>
</tr>
<tr>
<td>New II</td>
<td>0</td>
</tr>
<tr>
<td>QED</td>
<td>0</td>
</tr>
<tr>
<td>Simple Green®</td>
<td>20</td>
</tr>
<tr>
<td>Vortex®</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 5.7: Rating guidelines for the biobased content of product

<table>
<thead>
<tr>
<th>Rating</th>
<th>Contains the following % or threshold biobased content for product category</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Above 50% of biobased contents</td>
</tr>
<tr>
<td>4</td>
<td>Above 25% and up to 50% of biobased contents</td>
</tr>
<tr>
<td>3</td>
<td>Above AP threshold value and up to 25% of biobased contents</td>
</tr>
<tr>
<td>2</td>
<td>Equal AP threshold value (34%) of biobased content</td>
</tr>
<tr>
<td>1</td>
<td>Below AP threshold value of biobased content</td>
</tr>
<tr>
<td>0</td>
<td>Product does not contain biobased materials</td>
</tr>
</tbody>
</table>
Table 5.8: The score of test products with 34 percent biobased content as a threshold

<table>
<thead>
<tr>
<th>Product</th>
<th>Biobase Content Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>5</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>5</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>1</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>5</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>0</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>0</td>
</tr>
<tr>
<td>New II</td>
<td>0</td>
</tr>
<tr>
<td>QED</td>
<td>0</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>1</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>5</td>
</tr>
</tbody>
</table>

The test products that do not contain biobased content, which are Krud Kutter Original, N Methyl Pyrrolidone, New II and QED as shown in Table 5.7, will automatically get 0 for their scores. Bioact 113, Cello The Natural D-Limonene, d-Limonene, and Vortex ® have the similar chemical components, which are d-limonene or citrus terpene compounds. These compounds are 100% biobased materials. Therefore, these 4 products which have 100% biobased content and get a score of 5 as a rating, as shown in Table 5.7. 1 is the score for both Crystal Simple Green ® and Simple Green ®, which have 20% of biobased content.

5.2.4.3 Determine the score of applicability and performance record

For evaluating the performance of the test products, the test products have been provided to the employees who regularly use this type of product, which in this case are the employees in the Fabrication Shop. The evaluator needs to get the results in terms of the applicability of the test products to the projects and how well the test products
perform in the projects. Table 5.9 presents the scores of applicability and performance record of the products.

Table 5.9: The scores of test products for applicability and performance record

<table>
<thead>
<tr>
<th>Product</th>
<th>Score of Applicability</th>
<th>Score of Performance Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>New II</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>QED</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

N Methyl Pyrrolidone is the best test product when compared to the other products that receive the same score. Not only does it work well for removing grease, it also serves as a defluxer, adhesive remover and automotive degreaser. There is a mixed result for testing Bioact 113 and Krud Kutter Original; some of the employees comment about the residue left over from using these products, which may not be suitable for using in this facility, while others think that both products perform an adequate job for degreasing, but not as good as those test products that receive the higher scores. Thus, the score of 2 would be given to the test products that have mixed result, according to Table 3.3 and 3.4. Cello The Natural D-Limonene, Crystal Simple Green ® and Simple Green ® were in the ordering process to the facility, thus, these three products have not been tested yet.
5.2.4.4 Determine the score of capital costs

In this test case, the product costs and the shipping costs represent the capital costs for the test products. The highest capital costs in this test case are the capital costs of methylene chloride, assumed at $2,000 per 55-gallon drum. To determine the score of these test products, compare the percentage in capital costs of the test products to the methylene chloride and give the score according to Table 3.5. Table 5.10 shows the score of the capital costs criteria.

Table 5.10: The scores of test products for capital costs

<table>
<thead>
<tr>
<th>Product</th>
<th>Product Cost ($)</th>
<th>Shipping Cost ($)</th>
<th>Capital Cost ($)</th>
<th>% compare to MCl</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>1100</td>
<td>150</td>
<td>1250</td>
<td>62.5</td>
<td>1</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>650</td>
<td>105</td>
<td>755</td>
<td>37.75</td>
<td>3</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>786</td>
<td>80</td>
<td>866</td>
<td>43.3</td>
<td>2</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>694</td>
<td>102</td>
<td>796</td>
<td>39.8</td>
<td>3</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>874</td>
<td>130</td>
<td>1004</td>
<td>50.2</td>
<td>2</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>950</td>
<td>125</td>
<td>1075</td>
<td>53.75</td>
<td>2</td>
</tr>
<tr>
<td>New II</td>
<td>1210</td>
<td>100</td>
<td>1310</td>
<td>65.5</td>
<td>1</td>
</tr>
<tr>
<td>QED</td>
<td>1210</td>
<td>100</td>
<td>1310</td>
<td>65.5</td>
<td>1</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>786</td>
<td>80</td>
<td>866</td>
<td>43.3</td>
<td>2</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>995</td>
<td>100</td>
<td>1095</td>
<td>54.75</td>
<td>2</td>
</tr>
</tbody>
</table>

The cheaper capital cost of test products would result in the higher score in the capital cost criteria.
5.2.4.5 Determine the score of the operation and maintenance costs

Table 5.11 shows the score result of the test products for operation and maintenance costs. These operation and maintenance costs are compared to the costs of each test products in this test case. Generally, these test products receive a similar score because they have similar job functions, which are cleaning the grease off of materials. So, their costs for regular use would be about the same. Since these test products do not require special equipment to work, such as a ventilation system, they are basically no cost for maintenance. Some of the industrial cleaning products may require a ventilation system; thus, it requires the cleaning of the equipment that is used with the products, which can be considered a maintenance cost.

The shelf life of the test products is also important. The shorter the shelf life means the more unused quantities to be disposed of. Bioact 113, Cello The Natural D-Limonene, d-Limonene, and Vortex ® have a shelf life about 4 years when compared to the rest of the test products that have a shelf life of about 5 years; this would result in the difference in the scores.

The other difference in the scores of these test products is in the cost for disposal concerns with solid/hazardous waste minimization. Since Crystal Simple Green ® and Simple Green ® are biodegradable products and do not harm sewage-treatment microorganisms if disposed of by sewer or drain, the disposal cost would be cheaper compared to the other products that are not biodegradable. Also, the container of these two Simple Green ® products can be recycled or applied to other uses; this would generate less waste or help to improve minimization of waste.
Table 5.11: The scores of test products for O&M costs

<table>
<thead>
<tr>
<th>Product</th>
<th>Installation, training, material, supervision</th>
<th>PPE</th>
<th>Storage/expiration/price breaks/tax/other admin</th>
<th>Maintenance &amp; repairs</th>
<th>Regs., permits, treatment/disposal/SW, HW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>New II</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>QED</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

5.2.4.6 Determine the score of payback period

All 10 test products would get a high score. In this case they all rate at 5, in this payback period evaluation. The payback period of these test products happen immediately since all the 10 test products have a lower capital cost compared to the methylene chloride, also, assuming that the O&M costs of these test products are equal to or lower than the methylene chloride. Table 5.12 shows the score of the payback period.
Table 5.12: The scores of test products for payback period

<table>
<thead>
<tr>
<th>Product</th>
<th>Payback Period Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>5</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>5</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>5</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>5</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>5</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>5</td>
</tr>
<tr>
<td>New II</td>
<td>5</td>
</tr>
<tr>
<td>QED</td>
<td>5</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>5</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>5</td>
</tr>
</tbody>
</table>

5.2.4.7 Determine the score for recycle potential

These test products all have the potential to be recycled. The difference in the scores within this product-use category is due to the flammability issue of the products. The test products that have low flash point (in this case, <200 F) would result in flammability issue. They must be carefully stored and transported before going to the recycle process in order to reduce the risk of liability. The amount of costs and effort will be reduced in the recycle potential. Table 5.13 shows the score of the recycle potential.

Table 5.13: The scores of test products for recycle potential

<table>
<thead>
<tr>
<th>Product</th>
<th>Recycle Potential Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>4</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>4</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>5</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>4</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>4</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>4</td>
</tr>
<tr>
<td>New II</td>
<td>4</td>
</tr>
<tr>
<td>QED</td>
<td>4</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>5</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>4</td>
</tr>
</tbody>
</table>
5.2.4.8 Determine the score of solid waste minimization

Table 5.14 shows the score result of the test products for solid waste minimization. The most desirable products would have great potential for minimizing solid waste generation at the facility.

The test product that can be biodegradable would receive a high score in this parameter. The information for biodegradability of the products is showed in their MSDS. Less waste would be generated if the product can be biodegradable.

Even though, the test product does not provide the biodegradable information, this information can be determined via the ingredients in the product. In this case, Bioact 113 has d-limonene compounds which are considered as biodegradable compounds, but these compounds are not the whole ingredients of the product, so the score for the product must be lower than the product that shows validation of their biodegradability.

Landfill reduction is another parameter for scoring the test products. In this test case, consider the container’s material. The less packaging that will go to the landfill, the less landfill space that would be taken up. Crystal Simple Green ® and Simple Green ® both use plastic material in their containers which can be recycled or reused. Also, N Methyl Pyrrolidone uses steel as its container which can be recycled or reused. These three test products would rate at the same high score. The rest of the test products get rated at the lower score. Even though, they are using steel as their container’s material, these containers are lined with epoxy or phenolic resin which results in the complication of recycle process or they have to be thrown away.
Table 5.14: The scores of test products for solid waste minimization

<table>
<thead>
<tr>
<th>Product</th>
<th>Biodegradability/disassembly</th>
<th>Landfill reduction</th>
<th>Vendor packaging (less or recy)</th>
<th>Concentrate (more = less pkg/g)</th>
<th># ingred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>d-Limonene</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>New II</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>QED</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Vortex ®</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

5.2.4.9 Determine the score of hazardous waste minimization

The rating for these criteria may interpreted as, the higher degrees of the hazardous waste characteristics in terms of corrosivity, flammability, reactivity, and toxicity, in the test products, the lower rating in the hazardous waste minimization potential. If the test products is presented in any environmental regulatory listing for both the federal and state, it would affect the criteria scores. Table 5.15 shows the score result of the test products for hazardous waste minimization.
Table 5.15: The scores of test products for hazardous waste minimization

<table>
<thead>
<tr>
<th>Product</th>
<th>HAP/RCRA, SARA, CERCLA listed waste</th>
<th>State reporting</th>
<th>Corrosivity</th>
<th>Flammability</th>
<th>Reactivity</th>
<th>Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>New II</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>QED</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

N Methyl Pyrrolidone has the lowest score in the related issue for the hazardous waste regulations because it is listed in the TRI listing. Some states may require the products that contain certain chemicals to be reported on due to the states’ regulations. The test products that have to be reported due to the states’ regulations, this result would reduce the score of the products.

Crystal Simple Green ®, N Methyl Pyrrolidone, and Simple Green ® are the three products that have the scores in the corrosivity parameter.

Crystal Simple Green ® and Simple Green ® are rating at a high score in the flammability parameters because both of the products are non flammable. The rest of the test products have low flash point (<200 F) which may post potential danger in flammability issue.
All of the test products are stable at the normal condition. But a reaction that may pose a hazardous condition occurs when the test products react with either strong oxidizing agents or strong acids. Crystal Simple ® Green and Simple Green ® will not have any hazardous reactions. Thus, both of the test products rate at the high score.

This test case uses the measurement standard for the toxicity from Green Seal standard (GS-34: Degreasing Agents). If the product has a Oral LD50 ≤ 5,000 mg/kg rating, that product is considered toxic. Based on this criteria, most of these test products are not consider as toxic since their Oral LD50 is more than 5000 mg/kg, except N Methyl Pyrrolidone which has oral LD50 equal to 4150 mg/kg.

5.2.4.10 Determine the score of conservation criteria

The scores of conservation are rated in three parameters which are water use, energy use, and other resources use reduction. Table 5.16 shows the score result of the test products for the conservation criteria.

To determine the score for these criteria, the manufacture of the product will be considered into the score evaluation. Assume that the more ingredients/chemicals that are contained in the test products would require more energy and water for the manufacturers to process. Thus, less ingredients in a test product would yield a higher score in water, energy, and other resource use reduction.

The test products that have the ingredients which are the petroleum-based derived, their scores would be lower in the non-renewable resources criteria. Therefore, N Methyl Pyrrolidone, New II, and QED receive the lowest score in this criteria when compared to the rest of the test products.
The test products that use animals for testing the toxicity would yield a lower score in that criteria, since animals are considered a resource, and also adds the dimension of animal welfare.

Simple Green ® is the only one that adds the color (green) into the product which this would yield the lower score when compare with the rest.

**Table 5.16: The scores of test products for conservation criteria**

<table>
<thead>
<tr>
<th>Product</th>
<th>Water use reduction, incl vendor</th>
<th>Energy use reduction, incl vendor</th>
<th>Fragrnc/dye/unnecessary, incl # ingred, vend proceg</th>
<th>Non-renewable (incl. petrol solv), vend proceg</th>
<th>Non-animal-derived, incl vendor (eg testing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>New II</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>QED</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Simple Green ®</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Vortex ®</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>
5.2.4.11 Determine the score of facility EH & S criteria

There are three main criteria to be evaluated in this assessment factor: environmental emissions, health risk benefits, and safety hazard benefits. Table 5.17 shows the score result of the test products for these facility EH & S criteria. The scores will be based on the within-facility everyday standard use at GRC.

The test products that are the petroleum based will get a lower score for air emissions, which in this case, are N Methyl Pyroridone, New II, and QED. The VOCs (volatile organic compounds) content of the test products is the indicator for evaluating secondary pollutants. The test products that have VOC content would result in a lower score when compared to the others. In this test case, the test products which contain the d-limonene or citrus terpene would get a low score as they have a potential for generating secondary pollutants to the environment. Their VOC content would range from 750-850 gm/L as showed in Appendix A.

The toxicological data section from the test products’ MSDS are used for evaluating the score for water releases. The test products that are not biodegradable and are petroleum based would get a lower score when compared to the others that are biodegradable. Even though the products are biodegradable, it does not mean it will not be toxic to aquatic organisms. In this case, test products that are biodegradable and are not toxic to aquatic organisms would get a high score in this criteria.

There are several important parameters for evaluating health risk benefits criteria. Whether the ingredients is a carcinogen is one of these parameters that needs to be addressed first. In this test case, all of these test products are non carcinogenic and result in the same scores. The other parameters that relate to health risk benefits can be
evaluated by comparing toxicological information and hazard rating (NFPA/HMIS) standard of these test products, which is located in their MSDS materials in Appendix A. The scores of these parameters in the test products are relatively the same. Most of these test products have the NFPA Health rating = 1, which indicates the exposure of these products would cause irritation with only minor residual injury. Except, N Methyl Pyroridone and QED that have the potential risk as a developmental/reproductive toxin and neurotoxin, respectively. These two products would get a lower score in those parameters.

The scores for safety hazard benefits criteria are relevant to the scores in the hazardous waste minimization. The test products that contain less hazardous waste characteristics such as the corrosivity, flammability, and the reactivity, would yield the higher score in this criteria. The NFPA rating of the products are used to determine these hazardous waste characteristics. Crystal Simple Green ® and Simple Green ® are two products that get high scores in this criteria. Since their NFPA Flammability ratings are 0 this mean these products will not burn. Also the NFPA Reactivity ratings are 0 which mean these products are normally stable, even under fire exposure conditions, and are not reactive with water. These two products would increase the benefits of employees’ safety.
<table>
<thead>
<tr>
<th>Product</th>
<th>Env. Emission</th>
<th>Health risk benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air emissions, incl treat/disp &amp; vendor</td>
<td>Water releases, incl treat/disp &amp; vendor</td>
</tr>
<tr>
<td>Bioact 113</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Cello The Natural</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>D-Limonene</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Crystal Simple Green®</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>New II</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>QED</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Simple Green®</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Vortex®</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
5.2.4.12 Determine the score of environmental impact potential criteria

There are three main criteria to be evaluated in this assessment factor: bioaccumulation, environmental damage (regional), and global issues. Table 5.18 shows the score result of the test products for these environmental impact potential criteria. The focus here is on potential for regional and global environmental damage based on accidental release.

Since PBT (persistent bioaccumulative toxic) chemicals are one of the indicators for evaluating this parameter, the test products that contain these chemical will receive a lower score. But, they all contain this type of chemicals; thus, all of them receive the high score. The other indicator is the BCF (bioconcentration factor) rating for evaluating the score. N Methyl Pyrrolidone, Crystal Simple Green ®, and Simple Green ® are test products that provide this information; thus they would rate higher than the rest.

The score given in this environmental damage (region) are similar to the scores in the environmental emissions (local) of the facility EH&S criteria. The test products that are listed in the TRI list would receive the lower score, which is N Methyl Pyrrolidone.

All test products here have the potential for creating acid rain and global warming since all of them are the products of industrial processes which may be one of the sources for creating the these effects in the environment. All of the test product would be rated equally.

Ozone depletion chemicals are an indicator for scoring the test products in one of the global issue criteria. All of the test products do not contain and use these chemicals; thus, the scores of the test products would rate at the highest score.
Table 5.18: The scores of test products for environmental impact potential criteria

<table>
<thead>
<tr>
<th>Product</th>
<th>Bioaccumulation (BCF)</th>
<th>Environmental damage (Region)</th>
<th>Global Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bioact 113</td>
<td>Cello The Natural D-Limonene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Crystal Simple Green ®</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
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<tr>
<td></td>
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<td>3</td>
<td></td>
</tr>
<tr>
<td>d-Limonene</td>
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<td>3</td>
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<td></td>
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<tr>
<td></td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Krud Kutter Original</td>
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<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
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<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>New II</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
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</tr>
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<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
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<td></td>
</tr>
<tr>
<td>QED</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
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<td></td>
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<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>3</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Vortex ®</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2</td>
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<td></td>
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<td></td>
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<tr>
<td></td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
5.2.4.13 Determine the score of compliance criteria

There are three main criteria to be evaluated in this assessment factor: regulatory benefits, executive orders (EO) and NASA policy benefits, and liability benefits. Table 5.19 shows the score result of the test products for these compliance criteria.

The test products that are listed in any of the federal, state, or local regulations would result in a lower score for the regulatory benefit. All the test products are listed in the TSCA; thus the products in this parameter should be rated equally. N Methyl Pyrrolidone has the lowest score in this parameter, since it lists in the TRI list (EPCRA section 313).

The scores in the executive order (EO) and NASA policy benefit can use the results from other main assessment factors. For example, the scores from the AP criteria may use as the scores for NPG 8830.1-affirmative procurement plan. The products that generally contain hazardous compounds usually receive a lower score in this compliance criteria.

The lower the hazardous or toxic content in the products, the higher the score in the liabilities benefits. The products that contain those hazardous or toxic components have the potential to cause danger to employees and clean up costs from improper disposal of those products. In this case, N Methyl Pyrrolidone is the lowest score, since it is in the TRI list which relates to the hazardous waste issue, and has a potential to cause reproductive problems to employees who may be exposed to these chemicals.

Table 5.20 shows the summary score for these 10 test products
Table 5.19: The scores of test products for compliance criteria

<table>
<thead>
<tr>
<th>Product</th>
<th>Regulatory benefit</th>
<th>EO &amp; Policy Benefit</th>
<th>Reduced liab.’s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RCRA, CERCLA, SARA, OSHA</td>
<td>EO 12002, 12002</td>
<td>RCRA, CERCLA, SARA, OSHA</td>
</tr>
<tr>
<td>Bioact 113</td>
<td>3 3 2</td>
<td>4 2 2 3 4 3 3 3 4 3 3</td>
<td>4 4 4 5 3 3 3 3</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>3 3 2</td>
<td>4 2 4 2 3 3 3 4 4 4</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>Crystal Simple Green®</td>
<td>3 4 3</td>
<td>4 3 3 3 5 2 3 3 3 3</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>3 3 2</td>
<td>4 3 3 4 4 3 3 4 4 4</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>Krud Kutter Original</td>
<td>2 3 3</td>
<td>4 2 2 4 2 3 3 3 4 4</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>N Methyl Pyrrolidone</td>
<td>2 2 2</td>
<td>1 3 3 3 5 2 3 3 3 3</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>New II</td>
<td>2 3 3</td>
<td>4 3 3 1 2 3 3 3 4 4</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>QED</td>
<td>3 3 3</td>
<td>1 3 3 1 2 3 3 3 4 4</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>Simple Green®</td>
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<td>4 3 3 3 5 2 3 3 3 3</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
<tr>
<td>Vortex®</td>
<td>3 3 2</td>
<td>4 2 2 4 5 3 4 3 4 4</td>
<td>4 4 4 4 4 4 4 4 4 4</td>
</tr>
</tbody>
</table>
Table 5.20: The Score Summary of 10 Test Products: Heavy Duty Cleaning/Degreasers

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioact 113</td>
<td>Petroferm Inc.</td>
<td>55.2</td>
</tr>
<tr>
<td>Cello The Natural D-Limonene</td>
<td>Sherwin Williams Chem.</td>
<td>59.2</td>
</tr>
<tr>
<td>Crystal Simple Green®</td>
<td>Sunshine Makers, Inc.</td>
<td>60.5</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>Florida Chemical Co. Inc.</td>
<td>63.3</td>
</tr>
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<td>Krud Kutter Original</td>
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<td>Ecolink Inc.</td>
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<td>2.00</td>
<td>4.40</td>
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Weighting Factor:  

|                      | 1.0 | 1.0 | 0.6 | 0.6 | 0.8 | 0.8 | 0.8 |

Where Total Score = Sum of each main criteria score
Table 5.20: The Score Summary of 10 Test Products: Heavy Duty Cleaning/Degreasers (Continued)

<table>
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<tr>
<th>Meeting Goals</th>
<th>Conservation</th>
<th>Facility EH&amp;S</th>
<th>Env. Impact, Pot'l</th>
<th>Compliance</th>
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</table>

1.0 1.0 1.0 0.6 0.6 0.6 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8
5.3 EPP+ Program With Using the Web-Based Application Tool

Access the EPP+ program and input all the weighting factors and scores of the 10 test products into ‘Product Management’ section as shown in Figure 5.1. Then, go to the ‘Product Replacement’ section and type in Methylene Chlorine the targeted for replacement and select the ‘Cleaners: Heavy Duty Degreaser’ as the Product Category as shown in Figure 5.2. Then, select the main criteria that is related to the user’s desire. The defaulted program will be selected by examining all of the main criteria for replacing the Methylene Chloride, and the total scores of the 10 products will be displayed as shown in Figure 5.3.

Figure 5.1 Product Management for Cleaners: Heavy Duty Degreaser
Figure 5.2 Product Replacement for Cleaners: Heavy Duty Degreaser

Figure 5.3 Result for Cleaners: Heavy Duty Degreaser
The result is displayed in Figure 5.3 by ranking and by rating of these 10 products. The highest score in each main criteria is highlighted in green. For example, d-Limonene is the highest ranked among all 10 test products. It has a total score of 63.29 and its listed price is $694.00 per 55-gallon drum. Also it gets the highest scores in Affirmative Procurement (AP), Performance, and Price, which are 10.00, 6.00, and 9.92, respectively. If the user wants to know more about d-Limonene, he or she can access the manufacturer’s website of this d-Limonene by clicking at the product name.

Since this program allows users to select the criteria that is related to what they desire, the user can select the criteria that is related to their needs. To do this, the user selects his or her desired criteria by selecting the ‘Yes’ icon on the Product Replacement section, also, the criteria that are not desirable can be selected with the ‘No’ icon. This is a decision making tool so the users can select the appropriate criteria that will meet their needs. Various results from selecting among the different criteria will be shown as follows:
- **Price Only**

If Price is the only concern for the users, select ‘Yes’ for Price and for the rest select ‘No’. Figure 5.4 shows the result for the Cleaning: Heavy Duty Degreaser where Price is the only desirable criteria. In this case, Cello The Natural D-Limonene and d-Limonene received the highest score (9.92) for this criteria when compared to the rest of the test products.

![Figure 5.4 Price is selected as the only desirable criteria in Cleaners: Heavy Duty Degreaser](image)

- Affirmative Procurement (AP) [22]  
  - Yes  
  - No
- Compliance [23]  
  - Yes  
  - No
- Conservation [23]  
  - Yes  
  - No
- Environmental Impact - Potential [2]  
  - Yes  
  - No
- Facility EH&ES [2]  
  - Yes  
  - No
- Meeting Goals [2]  
  - Yes  
  - No
- Performance [2]  
  - Yes  
  - No
- Price [2]  
  - Yes  
  - No

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<tr>
<th>Rank</th>
<th>Product</th>
<th>Cello The Natural D-Limonene</th>
<th>d-Limonene</th>
<th>Crystal Simple Green Cleaning and Degreasing</th>
<th>Simple Green Cleaning and Degreasing</th>
<th>Krud Kutter - Original</th>
<th>Methyl Pyrrolidone</th>
<th>Vortex</th>
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<td>8.32</td>
<td>8.32</td>
<td>8.32</td>
<td></td>
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</tbody>
</table>

![Product Price Table](image)
**Affirmative Procurement (AP) Only**

If the Affirmative Procurement (AP), which is related to recycled and biobased content in the products, is the only concern for the users, select ‘Yes’ for AP and for the rest select ‘No’. Figure 5.5 shows the result for the Cleaning: Heavy Duty Degreaser where AP is the only desirable criteria. In this case, Cello The Natural D-Limonene, d-Limonene, and Vortex received the highest score (10.00) for this criteria when compared to the rest of the test products.

![Table](image)

**Figure 5.5 AP is selected as the only desirable criteria in Cleaners: Heavy Duty Degreaser**
Performance Only

If Performance is the only concern for the users, select ‘Yes’ for Performance and for the rest select ‘No’. Figure 5.6 shows the result for the Cleaning: Heavy Duty Degreaser where Performance is the only desirable criteria. In this case, d-Limonene, N-Methyl Pyrrolidone, New II, QED, and Vortex received the highest score (6.00) for this criteria when compared to the rest of the test products.

Figure 5.6 Performance is selected as the only desirable criteria in Cleaners: Heavy Duty Degreaser
• Environmental Impact with Health and Safety Issues

If environmental, health and safety issues are the criteria that concern users, select ‘Yes’ for Conservation, Environmental Impact Potential, and Facility EH&S and for the rest select ‘No’. Figure 5.7 shows the results for the Cleaning: Heavy Duty Degreaser where environmental and health and safety related issues are desirable criteria. In this case, Crystal Simple Green ® and Simple Green ® received the highest score, 9.65 and 9.81 for Environmental Impact Potential and Facility EH&S, respectively. Cello The Natural D-Limonene received the highest score (5.80) in Conservation when compared to the rest of the test products.

Figure 5.7 Environmental, Health and Safety are selected as the desirable criteria in Cleaners: Heavy Duty Degreaser
 Goals and Compliance Issue

If achieving the goals for the organization and complying with all the regulations and policies are concerns for the users, select ‘Yes’ for Meeting goals and Compliance, and for the rest select ‘No’. Figure 5.8 shows the result for the Cleaning: Heavy Duty Degreaser where Meeting Goals and Compliance are the desirable criteria. Crystal Simple Green ® and Simple Green ® are the two products that received the highest score, 7.90 and 12.75 for Compliance and Meeting Goals, respectively, when compared to the rest of the test products.

Figure 5.8 Meeting Goals and Compliance are selected as the desirable criteria in Cleaners: Heavy Duty Degreaser
6.1 Summary

An EPP+ protocol has been developed in this study, which was designed as a web-based application that evaluates life-cycle factors, affirmative procurements, price and performance of off-the-shelf products that impact or benefit the environment and human health.

This protocol has been developed based on the principles of Environmentally Preferable Purchasing (EPP) and using the combined qualitative/quantitative Life Cycle Assessment (LCA) scoring method. There are 8 main criteria to be scored/evaluated in the LCA scoring system, which are Affirmative Procurement, performance, price, meeting goals, conservation, facility environmental, health, and safety (EH&S), environmental impact potential, and compliance issues.

In the scoring system, each criteria is weighed according to the relative seriousness of that criteria. The prioritizing among different criteria depends on the values of the person or the panel of experts who want(s) to weigh the impact. In this
protocol, the weighting factors in this evaluation process of this protocol are selected by
the evaluators in consideration of the evaluators’ goals. Those goals are usually based on
the priorities of the management of the evaluators’ organizations. Once the scores for
each criteria have been multiplied by their appropriate weighing factors, all the scores can
be added together to provided an total score for this EPP+ program.

The protocol will aid the evaluators (the experts) in evaluating and scoring
environmentally preferable products. It will also help users (non-experts) to select
products rated by the experts, thereby providing a tool to make more sustainable product
decisions.
6.2 Engineering Significance

This EPP+ protocol is an important tool for evaluating the environmentally preferable products and services for the following reasons;

• It can be a dominant design. The program would help promote the use of the products that are environmentally-friendly in the community, which results in a better environment, better health, and better economic perspective (i.e. less waste to clean up) as well as more sustainable development in our society;
• The program incorporates all the important ideas related to Life Cycle impacts, benefiting the evaluation process;
• The program is in a simple form for both experienced evaluators and regular users. Since the scores are represented by numerical values, the results from the program show the products’ rankings and rating scores. This makes the information easy to visualize;
• The program is flexible, illustrated by its ability to add unlimited criteria, categories, and products, and is built for future use.
6.3 Future Works

This study presented the EPP+ program in the form of the web-based application. Although the application is completely developed, there are the future works that can be done for this application to be more functional and for improvement.

- This application can be converted to the general LCA, from gate to cradle LCA converted to cradle to cradle concept.
- This application can be adopted to the other industry, not limited to the off-the-shelf product, such as helping the formulation process for making the better paint in the paint industry.
- This application can be applied to the Green Chemistry production, results in the safer ingredients, safer environment, sustainable development in the communities.
- The category will be expanded more than the initial 5 categories that will suit to all the products in the different industry.
- The scale of the score, originally from 0 to 5, may change to 0 to 6 for equally distribution of the positive and negative impacts of each criteria score.
BIBLIOGRAPHY


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http://www.epa.gov/opptintr/epp/about/about.htm


http://www.epa.gov/oppt/epp/pubs/guidance/finalguidancedoc.html
   http://www.epa.gov/oppt/epp/tools/gentt/textver/topic2.html

   http://www.epa.gov/oppt/epp/tools/gentt/textver/topic7.html

   http://www.epa.gov/nrmrl/lcaccess/lca101.html

   http://www.epa.gov/oaintrnt/practices/eo13423.htm

   http://www.epa.gov/epp/pubs/about/about.htm


APPENDIX A

MSDS of 10 Test Products
## MSDS of Bioact 113

### Safety Information

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### Responsible Party

**Name:** PETROFERM INC

**Address:**

5415 FIRST COAST HWY

**City:** FERNANDINA BEACH

**State:** FL

**Zip:** 32034

**Country:** US

**Info Phone Number:** 904-261-8286

**Emergency Phone Number:** 202-483-7616; 100-424-9308 (CEEMTREC)

### Radiactive Info

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### Preparer's Name

N/P

### Proprietary Info

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| Review Ltd | N |

### Published

Y

### Special Project CD

N

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</table>

### Country

US

**Phone:** 904-261-8286

### Ingredients
Case: 089-27-5  M  G06300100  M

Code:  RTEES #  Code:
Name:  CYCLOHEXENE, 1-METHYL-4-(1-METHYLETHENYL)-, (E)- 1-METHYL-4-(1-METHYLETHENYL)-CYCLOHEXENE. LES(0.01LM, RAT) >5.00 MG/KG

% Text:  25-45  Environmental Wt:

OSHA PEL:
N/K (FP N)  Code:  M  OSHA STEL.  Code:

ACGIHTLV:  N/K (FP N)  Code:  M  ACGIH NFT  STEL.  Code:

EPA Rpt Qty:
DOT Rpt Qty:
Owner Dephthing Chemically:
N

Case: 5088-52-7  M  X

Code:  RTEES #  Code:
Name:  1-T-BUTOXY-2-PROANOL

% Text:  55-75  Environmental Wt:

OSHA PEL:
N/K (FP N)  Code:  M  OSHA STEL.  Code:

ACGIHTLV:  N/K (FP N)  Code:  M  ACGIH NFT  STEL.  Code:

EPA Rpt Qty:
DOT Rpt Qty:
Owner Dephthing Chemically:
N

Health Hazards Data

LD50 (LC50) Dose:

SEE INGREDIENT 1

Route Of Entry Inds – Inhalation: YES  Skin: YES  Ingestion: YES

Carcinogenicity Inds – NTP: NO  IARC: NO  OSHA: NO
Health Hazards Acute And Chronic

ACUTE: INHALATION—ACUTE OR CHRONIC INHALATION IN UNVENTILATED AREAS MAY CAUSE IRRITATION OF RESPIRATORY TRACT. DIGESTION: LOW ORDER OF TOXICITY, MAY CAUSE MILD NAUSEA AND ABDOMINAL DISCOMFORT. SKIN: EXCESSIVE SKIN CONTACT WILL REMOVENATURAL SKIN OILS WHICH COULD LEAD TO REVERSIBLE DERMATITIS. EYES: (CITY OF OVEREXP)

Explanation Of Carcinogenicity

NOT RELEVANT.

Signs And Symptoms Of Overexposure

HEALTH HAZ: CONTACT WITH EYES WILL CAUSE IRRITATION

Medical Cond Aggravated By Exposure

NONE SPECIFIED BY MANUFACTURER.

First Aid

INHAL: REMOVE TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN. CONSULT PHYS. IMMEDIATELY. DO NOT INDUCE VOMITING. SEEK MEDICAL ATTENTION. SKIN: REMOVE CONTAMINATED CLOTHES. THOROUGHLY WASH AFFECTED AREA WITH SOAP & WATER. USE SKIN CREAM IF IRRITATION IS SEVERE. EYES: IMMEDIATELY FLUSH WITH WATER FOR AT LEAST 15 MINUTES. CALL PHYS. IF IRRITATION PERSISTS.

Spill Release Procedures

ABSORB SPILL WITH INERT MATERIAL, THEN PLACE IN CHEMICAL WASTE CONTAINER. FOR LARGE SPILLS, CALL FOR LATEE DISPOSAL. OBSERVE GOVERNMENT REGULATIONS.

Neutralizing Agent

NONE SPECIFIED BY MANUFACTURER.

Waste Disposal Methods

WASTE TREAT OR INCINERATE USED MATERIAL IN COMPLIANCE WITH ALL APPLICABLE FEDERAL, STATE AND LOCAL REGULATIONS.

Handling And Storage Precautions

STORE IN ORIGINAL CONTAINER, PREFERABLY IN A COOL, VENTILATED, FIRE-RESISTANT BUILDING. AVOID OVERHEATING OR FREEZING.

Other Precautions
AVOID OPEN FLAMES AND SPARKS. SINCE EMPTY CONTAINERS MAY RETAIN PRODUCT RESIDUES (VAPOR, LIQUID, OR SOLID), ALL LABEL PRECAUTIONS MUST BE OBSERVED.

Flash Point Method:

FMCC

Flash Point: 112F

Autoignition Temp: N/A

Lower Limits: N/K

Upper Limits: N/K

Extinguishing Media

DRY CHEMICAL, CHEMICAL FOAM, CARBON DIOXIDE. CLASS BC, ABC FIRE EXTINGUISHER.

Fire Fighting Procedures

USE RIOH11 APPROVED SCHA & FULL PROTECTIVE EQUIPMENT (FP N).

UNUSUAL FIRE/EXPLOSION HAZARD

EXERCISE CARE WHEN DISPOSING OF RAGS CONTAMINATED WITH THIS PRODUCT. USE NORMAL PRECAUTIONS APPROPRIATE FOR OILY RAGS.

Respiratory Protection

USE RIOH11 APPROVED RESPIRATOR IF VENTILATION IS NOT SUFFICIENT AND IF MISTS ARE GENERATED.

VENTILATION

IF DESIRABLE TO REDUCE ODOUR, MECHANICAL (GENERAL) VENT SHOULD HAVE AIRFLOW OF 55 CFM. LOCAL EXHAUST CAN ALSO BE (SUDDAT)

Protective Gloves

CHEMICALLY RESISTANT GLOVES.

Eye Protection

ANSI APPROVED CHEMICAL GOGGLES (FP N).
Work Hygienic Practices

NONE SPECIFIED BY MANUFACTURER.

Supplemental Safety and Health

% VOLATILE: 100% (BY WT). VENT EFFECTIVE IN MINIMIZING ODOR.

<table>
<thead>
<tr>
<th>Physical &amp; Chemical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCC:</td>
</tr>
<tr>
<td>NLC/State LIC No.</td>
</tr>
</tbody>
</table>

Net Prop WT For Ammonia:

- Boiling Point: B.P. Text: >364°F, >151°C
- Melting Point: M.P. E.P. Text: N/K
- Decomposition Temp: Decomp. Temp: N/K
- Vapor Press.: <2
  - Vapor Density: >1
- Volatile Org Content %: Spec. Gravity: 0.86 at 77°F
  - VOC Parts/Gallon: P/I: N/K
  - VOC Parts/Liter: Viscosity: N/K

Evaporation Rate & Reference:

Solubility in Water: INSOLUBLE

Appearance and Odor: COLORLESS TO LIGHT YELLOW LIQUID WITH A MILD CITRUS ODOR.

Percent Volatiles by Volume: SUPTA: 1.0
  - Corrosion Rate: N/K

Stability Indication

YES
Stability Condition To Avoid: TEMPERATURES ABOVE 304F(151C).

Materials To Avoid: STRONG MINERAL ACIDS AND STRONG OXIDIZING AGENTS.

Hazardous Decomposition Products: NONE OTHER THAN NORMAL PRODUCTS OF COMBUSTION.

Hazardous Polymerization Indicator: NO

Conditions To Avoid Polymerization NOT RELEVANT.

==================================================================================================

Toxicological Information
N/P

==================================================================================================

Ecological Information
N/P

==================================================================================================

Transport Information
N/P

==================================================================================================

Regulatory Information
N/P

==================================================================================================

Sara Title III Information:
N/P

Federal Regulatory Information: N/P

State Regulatory Information: N/P

==================================================================================================

Other Information
N/P

==================================================================================================

Print Label:


Product ID:

BIOACT 113 PRECISION CLEANER

Cage: 0WUA8  Assigned IND: N
Company Name: PETROFERM INC
COMBUSTIBLE. ACUTE INHALATION: ACUTE OR CHRONIC INHALATION IN UNVENTILATED AREAS MAY CAUSE IRRITATION OF THE RESPIRATORY TRACT. INGESTION: LOW ORDER OF TOXICITY. MAY CAUSE MILD NAUSEA AND ABDOMINAL DISTRESS. SKIN: EXCESSIVE SKIN CONTACT WILL REMOVED NAIL NATURAL SKIN OILS WHICH COULD LEAD TO REVERSIBLE DERMATITIS. EYES: CONTACT WITH EYES WILL CAUSE IRRITATION.

CHRONIC IRRITATION OF RESPIRATORY TRACT.

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MSDS of Cello 1228 D-Limonene

MATERIAL SAFETY DATA SHEET

The Natural D-Limonene Degreaser

PRODUCT NAME: The Natural D-Limonene Degreaser

PRODUCT CODE: Cello 1228

PRODUCT CLASS: Liquid Cleaning Compound

MANUFACTURER’S NAME: Cello Professional Products, Sherwin Williams Chemical Business Unit

ADDRESS: 1324 Old Post Rd, Hanco, MD 21078

EMERGENCY PHONE: 800-622-3555

CHEMICAL PHONE: 800-348-9000

INFORMATION PHONE: 410-839-1243

DATE OF PREPARATION: 7/30/10

NAME OF PREPARE: Technical Department

REPORTABLE COMPONENTS:

<table>
<thead>
<tr>
<th>CAS NUMBER</th>
<th>VAPOR PRESSURE</th>
<th>VAPOR DENSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* indicates toxic chemical(s) subject to the reporting requirements of section 313 of Title III and section 312 of CERCLA.

SECTION II - HAZARDOUS INGREDIENTS/SARA III INFORMATION

SARA III INFORMATION:

<table>
<thead>
<tr>
<th>HAZARD CODE</th>
<th>AMOUNT</th>
<th>REPORTABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* indicates hazardous chemical(s) subject to the reporting requirements of section 313 of Title III and section 312 of CERCLA.

SECTION III - PHYSICAL/CHEMICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>BOILING POINT</th>
<th>124°F C</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAPOR DENSITY</td>
<td>HIGH THAN AIR</td>
</tr>
<tr>
<td>EVAPORATION RATE</td>
<td>SLOWER THAN WATER</td>
</tr>
<tr>
<td>APPEARANCE</td>
<td>CLEAR ORLIQUID</td>
</tr>
<tr>
<td>ODOR</td>
<td>ORANGE</td>
</tr>
<tr>
<td>pH</td>
<td>NOT TESTED</td>
</tr>
</tbody>
</table>

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: 110°F

FLASH METHOD: SETA FLASH

FLASH LIMITS IN AIR BY VOLUME: LOWER: 1 UPPER: 5.1

EXTINGUISHING MEDIA: IF INVOLVED IN A FIRE USE FOAM, CO2, WATER FOG

SPECIAL FIREFIGHTING PROCEEDURES: Wear self-contained breathing apparatus. Use water spray to cool containers involved in fire.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Area will become slippery if material is released.

SECTION V - REACTIVITY DATA

STABILITY: STABLE

CONDITIONS TO AVOID: SPARKS OR OPEN FLAME

INCOMPATIBILITY: MATERIALS TO AVOID: ACIDS, STRONG ALKALIES AND OXIDANTS

HAZARDOUS DECOMPOSITION OR BYPRODUCTS: NITROGEN, CARBON DIOXIDE, CARBON MONOXIDE

HAZARDOUS POLYMERS: MAY OCCUR

SECTION VI - HEALTH HAZARD DATA

INHALATION HEALTH RISKS AND SYMPTOMS OF EXPOSURE: HIGH CONCENTRATIONS IRRITATING TO THE EYES AND RESPIRATORY TRACT. MAY CAUSE HEADACHE, DIZZINESS, NAUSEA AND VOMITING.

SKIN AND EYE CONTACT HEALTH RISKS AND SYMPTOMS OF EXPOSURE: CORRODE TO SKIN, COULD CAUSE BURNING IF DRIED IN EYES.

SKIN ABSORPTION HEALTH RISKS AND SYMPTOMS OF EXPOSURE: ABSORPTION THROUGH SKIN MAY CAUSE HEADACHE, NAUSEA, DIZZINESS AND VOMITING.

INGESTION HEALTH RISKS AND SYMPTOMS OF EXPOSURE: MAY CAUSE PERMANENT INJURY BY DAMAGING BONE, TRACT, ESOPHAGUS AND MUCOSA.

HEALTH HAZARDS [ACUTE AND CHRONIC]: CONTACT WITH EYES CAN CAUSE CORNEAL DAMAGE. EXPOSED TOXIC Fumes CAN CAUSE KIDNEY, LIVER DAMAGE.

COOKING, HEADACHES, NAUSEA, VOMITING

CARCINOGENICITY: NTP CARCINOGEN: NO IARC MONOGRAPHS: NO OSHA REGULATED: NO NOT LISTED

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: MAY AGGRAVATE EXISTING CONDITIONS OF DERMATITIS AND/OR LIVER OR KIDNEY DISORDERS.

EMERGENCY AND FIRST AID PROCEDURES:

IF IN EYES: Immediately flush with plenty of warm water for 15 minutes while keeping eyelids apart for maximum irrigation. If irritation persists contact physician.

IF IN RESPIRATORY: Use appropriate protective equipment.

IF INHIBITED: If skin contact occurs, flush with warm water. If irritation persists consult a physician. If eye contact occurs flush with plenty of water for 15 minutes while keeping eyelids apart. Do not rub eyes. If irritation persists consult a physician.

IF INGESTED: Drink large amounts of fruit juices or milk following by large quantities of milk or egg whites. Do not induce vomiting. Contact physician.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Remove sources of ignition. Shunt area to contain material. Area may become slippery. Neutralize by adding dilute solutions of the following acids: Muriatic acid, acetic acid. Absorb product into porous material such as sand, dibasic acid or commerical absorbent material. Shove up into slack proof containers.

WASTE DISPOSAL METHOD: Consult local, state and/or federal authorities for proper disposal.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING: Store away from excessive heat and extreme cold. Keep away from sparks and open flames in well ventilated area. Do not store near combustibles. Keep out of reach of children.

OTHER PRECAUTIONS: Use self-contained breathing apparatus. Use in a manner consistent with product intent.

SECTION VIII - CONTROL MEASURES

RESPIRATORY PROTECTION: FOR PERSONAL USE, A N95 RESPIRATOR IS RECOMMENDED.

VENTILATION: GOOD VENTILATION IS REQUIRED. IN THE ABSENCE OF GOOD VENTILATION MECHANICAL DEVICES ARE RECOMMENDED.

PROTECTIVE GLOVES: CHEMICAL RESISTANT GLOVES RECOMMENDED.

EYE PROTECTION: SAFETY GLASSES OR GOGGLES RECOMMENDED.

OTHER PROTECTIVE CLOTHING OR EQUIPMENT: SOURCES OF WATER FOR WASHING IS RECOMMENDED.

WORK HYGIENE PRACTICES: WASH HANDS AFTER USE AND BEFORE EATING, DRINKING, OR SMOCKING. REMOVE CONTAMINATED CLOTHING AND WASH BEFORE REUSE.

SECTION IX - REGULATORY INFORMATION

ALL INGREDIENTS OF THIS PRODUCT ARE LISTED ON THE US TONG SUBSTANCE CONTROL ACT (TSCA) INVENTORY.

HAZARD CLASS: WHEN SHIPPED IN 1 GALLON CONTAINERS OR LESS: COMBUSTIBLE ORANGE.

LARGER THAN 1 GALLON: FLAMMABLE LIQUID, ROB (CONTAINS OELVEMA) 3, UN1099, P.O. 3

DOT LABEL: 1 GALLON CONTAINERS OR LESS: ORM-D

LARGER THAN 1 GALLON: ORM-A

The ingredients from Section 9 are subject to the following reporting requirements:

MA - The Massachusetts Hazardous Substance List
NJ - The New Jersey Right-To-Know Hazardous Substance List
PA - The Pennsylvania Hazardous Substance List

SECTION X - DISCLAIMER

The information contained herein has been developed based upon current available scientific data. The information may be developed from time to time which may render the conclusions of this report obsolete. Therefore, no warranty is extended or implied as to the applicability of this information to the users intended purpose or for the consequences of its use or misuse.

# MATERIAL SAFETY DATA SHEET: CRYSTAL SIMPLE GREEN®

*also for:* SIMPLE GREEN® SAFETY TOWELS

## I. PRODUCT & COMPANY INFORMATION

**PRODUCT NAME:** CRYSTAL SIMPLE GREEN®

**OTHER NAMES:** CRYSTAL SIMPLE GREEN® - SPECIALIZED CLEANER / DEGREASER  
SIMPLE GREEN® SAFETY TOWELS (fluid only)

**COMPANY NAME:** SUNSHINE MAKERS, INC.  
15922 Pacific Coast Highway  
Huntington Harbour, CA 92649 USA  
Telephone: 800-228-0799 • 562-756-8000  
Fax: 562-692-3034  
Website: www.simplegreen.com

For 24-hour emergency, call Chem-Tel, Inc.: 800-255-3924

**USE OF PRODUCT:** A specialized cleaner and degreaser for use in the industrial and institutional workplace. (Simple Green® Safety Towels contain diluted Crystal Simple Green®.)

## II. INGREDIENT INFORMATION

The only ingredient of Crystal Simple Green® with established exposure limits is undiluted 2-butoxyethanol (<6%) (Butyl Cellosolve; CAS No. 111-76-2 the ACGIH TLV-TWA is 20 ppm (97 mg/m³). The quantity of 2-butoxyethanol in Simple Green Safety Towels is <1%.

Based upon chemical analysis, Crystal Simple Green® contains no known EPA priority pollutants, heavy metals, or chemicals listed under RCRA, CERCLA, or CWA. Analysis by TCLP (Toxicity Characteristic Leaching Procedure) according to RCRA revealed no toxic organic or inorganic constituents.

All components of Crystal Simple Green® are listed on the TSCA Chemical Substance Inventory.

## III. HAZARDS IDENTIFICATION

<table>
<thead>
<tr>
<th>Hazard Ratings (NFPA/HMIS)</th>
<th>Rating Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health = 1*</td>
<td>0 = minimal</td>
</tr>
<tr>
<td>Fire = 0</td>
<td>2 = moderate</td>
</tr>
<tr>
<td>Reactivity = 0</td>
<td>4 = severe</td>
</tr>
</tbody>
</table>

*Mild eye irritant, non-mutagenic and non-carcinogenic: None of the ingredients in Crystal Simple Green® are regulated or listed as cancer agents by Federal OSHA, NTP, or IARC.
IV. FIRST AID MEASURES

SYMPTOMS OF OVEREXPOSURE AND FIRST AID TREATMENT

Eye contact: Reddening may develop. Immediately rinse the eye with large quantities of cool water: continue 10-15 minutes or until the material has been removed; be sure to remove contact lenses, if present, and to lift upper and lower lids during rinsing. Get medical attention if irritation persists.

Skin contact: Minimal effects, if any; rinse skin with water, rinse shoes and launder clothing before reuse. Reversible reddening may occur in some dermal-sensitive users; thoroughly rinse area and get medical attention if reaction persists.

Swallowing: Essentially non-toxic. Give several glasses of water to dilute; do not induce vomiting. If stomach upset occurs, consult physician.

Inhalation: Non-toxic. Exposures to concentrate-mist may cause mild irritation of nasal passages or throat; remove to fresh air. Get medical attention if irritation persists.

V. FIRE FIGHTING MEASURES

Crystal Simple Green® is stable, not flammable, and will not burn.

Flash Point/Auto-Ignition: Not flammable.

Flammability Limits: Not flammable.

Extinguishing Media: Not flammable/explosive. No special procedures required.

Special Fire Fighting Procedures: None required.

VI. ACCIDENTAL RELEASE MEASURES

Recover usable material by convenient method; residual may be removed by wipe or wet mop. If necessary, unrecoverable material may be washed to drain with large quantities of water.

VII. HANDLING, STORAGE & TRANSPORT INFORMATION

No special precautions are required. This product is non-hazardous for storage and transport according to the U.S. Department of Transportation Regulations. Crystal Simple Green® requires no special labeling or placarding to meet U.S. Department of Transportation requirements.

UN Number: Not required

Dangerous Goods Class: Nonhazardous

VIII. EXPOSURE CONTROLS

Exposure Limits: The Crystal Simple Green® formulation presents no health hazards to the user when used according to label directions for its intended purposes. Mild skin and eye irritation is possible (please see Eye contact and Skin contact in Section IV.).

Ventilation: No special ventilation is required during use. Large-scale uses indoors should provide an increased rate of air exchange.

Human Health Effects or Risks from Exposure: Adverse effects on human health are not expected from Crystal Simple Green®, based upon twenty years of use of Simple Green without reported adverse health incidence in diverse population groups, including extensive use by inmates of U.S. Federal prisons in cleaning operations.

Crystal Simple Green® is a mild eye irritant; mucus membranes may become irritated by concentrate-mist.

Crystal Simple Green® is not likely to irritate the skin in the majority of users. Repeated daily application to the skin without rinsing, or continuous contact of Crystal Simple Green® on the skin may lead to temporary, but reversible, irritation.

Medical Conditions Aggravated by Exposure: No aggravation of existing medical conditions is expected, dermal-sensitive users may react to dermal contact by Crystal Simple Green®.
IX. PERSONAL PROTECTION

Precautionary Measures: No special requirements under normal use conditions.

Eye Protection: Caution, including reasonable eye protection, should always be used to avoid eye contact where splashing may occur.

Skin Protection: No special precautions required, rinse completely from skin after contact.

Respiratory Protection: No special precautions required except during large-scale spray applications where spray mist levels are high.

Work and Hygienic Practices: Wash or rinse hands before touching eyes or contact lenses. Follow standard hygienic practices for handling cleaning agents.

X. PHYSICAL AND CHEMICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance/odor</td>
<td>Clear liquid</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.020</td>
</tr>
<tr>
<td>pH of concentrate</td>
<td>9.35</td>
</tr>
<tr>
<td>Evaporation</td>
<td>&gt;1 (butyl acetate = 1)</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>100.6 °C (212 °F)</td>
</tr>
<tr>
<td>Freezing Point</td>
<td>-9 °C (16 °F)</td>
</tr>
<tr>
<td>Vapor Pressure</td>
<td>18 mm Hg @ 20 °C</td>
</tr>
<tr>
<td>Vapor Density</td>
<td>1.3 (air = 1)</td>
</tr>
<tr>
<td>Density</td>
<td>8.5 lbs./gallon</td>
</tr>
</tbody>
</table>

VOC Composite Partial Pressure: 0 mm Hg @ 20 °C

Volatile Organic Compounds (VOCs): 0 g/L, per ASTM Method 3960-90. Per EPA Method 24, VOCs are 5.9% and product must be diluted at least 1 part of water to 1 part Simple Green® in order to meet CARB 2005 VOC regulations -or- 1 part Simple Green to 3 parts water to meet SCAQMD Rule 1171 & Rule 1122 and BAAQMD Regulation 8-16 VOC requirements for solvent cleaning operations.

Safety Towel VOCs: Per EPA Method 24, VOCs are 0.5%.

Safety Towel pH: 8.1 - 8.8

Water Solubility: Crystal Simple Green® is completely soluble in water.

Detection: Crystal Simple Green® and Simple Green® Safety Towels have a characteristic odor that is not indicative of any hazardous situation.

XI. STABILITY AND REACTIVITY INFORMATION

Nonreactive. Crystal Simple Green® is stable, even under fire conditions, and will not react with water or oxidizers. Hazardous polymerization will not occur.

XII. TOXICOLOGICAL INFORMATION

The information and conclusions cited in this section are based on data and testing of Simple Green®. The data are directly applicable to Crystal Simple Green® because both formulations are virtually identical, except for fragrance and color.

Nonhuman Toxicity

Acute Mortality Studies:

Oral LD₅₀ (rat): >5.0 g/kg body weight
Dermal LD₅₀ (rabbit): >2.0 g/kg body weight

Dermal Irritation: Only mild, but reversible, irritation was found in a standard 72-hr test on rabbits. A value of 0.2 (non-irritating) was found on a scale of 8.

Eye Irritation: With or without rinsing with water, the irritation scores in rabbits at 24 hours did not exceed 15 (mild irritant) on a scale of 110.

Subchronic dermal effects: No adverse effects, except reversible dermal irritation, were found in rabbits exposed to Simple Green® up to 2.0 g/kg/day for 13 weeks applied to the skin of 25 males and 25 females. Only female body weight gain was affected. Detailed microscopic examination of all major tissues showed no adverse changes.

Fertility Assessment by Continuous Breeding: The Simple Green® formulation had no adverse effect on fertility and reproduction in CD-1 mice with continuous administration for 18 weeks, and had no adverse effect on the reproductive performance of their offspring.
SUNSHINE MAKERS, INC.  Crystal Simple Green® MSDS No. 4013

Page 4 of 4

XIII. BIODEGRADABILITY AND ENVIRONMENTAL TOXICITY INFORMATION

Biodegradability:
Like Simple Green®, Crystal Simple Green® is readily decomposed by naturally occurring microorganisms. The biological oxygen demand (BOD), as a percentage of the chemical oxygen demand (COD), after 4, 7, and 11 days was 56%, 60%, and 70%, respectively. Per OECD Closed Bottle Test, Crystal Simple Green® meets OECD and EPA recommendations for ready biodegradability.

In a standard biodegradation test with soils from three different countries, Butyl Cellosolve reached 50% degradation in 6 to 23 days, depending upon soil type, and exceeded the rate of degradation for glucose, which was used as a control for comparison.

Environmental Toxicity Information:
Crystal Simple Green® is considered practically non-toxic per EPA’s aquatic toxicity scale.

XIV. DISPOSAL CONSIDERATIONS

Crystal Simple Green® is fully water soluble and biodegradable and will not harm sewage-treatment microorganisms if disposal by sewer or drain is necessary. Dispose of in accordance with all applicable local, state, and federal laws.

XV. OTHER INFORMATION

Containers:
Crystal Simple Green® residues can be completely removed by rinsing with water; the container may be recycled or applied to other uses.

Contact Point:

National Stock Numbers:

<table>
<thead>
<tr>
<th>PART#</th>
<th>NSN</th>
<th>SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>19024</td>
<td>7930-01-418-1151</td>
<td>24 oz spray (12/cs)</td>
</tr>
<tr>
<td>19128</td>
<td>7930-01-418-1152</td>
<td>1 gal. (6/cs)</td>
</tr>
<tr>
<td>19005</td>
<td>7930-01-418-1153</td>
<td>5 gal.</td>
</tr>
<tr>
<td>19055</td>
<td>7930-01-418-1155</td>
<td>55 gal.</td>
</tr>
</tbody>
</table>

Simple Green Safety Towel Part Numbers:

<table>
<thead>
<tr>
<th>PART #</th>
<th>SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>13353</td>
<td>5-count pouch (50/cs)</td>
</tr>
<tr>
<td>13351</td>
<td>75-count canister (6/cs)</td>
</tr>
</tbody>
</table>

*** NOTICE ***

All information appearing herein is based upon data obtained by the manufacturer and recognized technical sources. Judgments as to the suitability of information herein for purchaser’s purposes are necessarily purchaser’s responsibility. Therefore, although reasonable care has been taken in the preparation of this information, Sunshine Makers, Inc. or its distributors extends no warranties, makes no representations and assumes no responsibility as to the suitability of such information for application to purchaser’s intended purposes or for consequences of its use.

MSDS of d-Limonene

Florida Chemical

d-Limonene
Technical, Food, and Lemon-Lime Grades

Product Data Sheet

November 2004

DESCRIPTION

d-Limonene is a biodegradable solvent occurring in nature as the main component of orange peel oil. d-Limonene's positive environmental profile and pleasant orange aroma have earned the product acceptance in many diverse chemical applications. d-Limonene can be used in its pure form, blended with other solvents, or easily emulsified to make water soluble cleaning products.

APPEARANCE & ODOR

Clear water-white to slightly yellow liquid with a mild to strong orange aroma depending on grade.

USES & APPLICATIONS

d-Limonene can be used to replace toxic, hazardous, and dangerous petroleum-derived chemicals. Ideal for use as parts cleaner, engine degreaser (automotive, aircraft, and aerospace industries), electronics cleaner, tar cleaner, asphalt release agent, graffiti remover, grease trap maintainer, heat transfer fluid, lift station and sewage treatment solvent.

d-Limonene is excellent in household, institutional and industrial product formulations such as: hand cleaner, glass cleaner, hard surface cleaner, floor cleaner, printing press wash, carpet/stain cleaner, metal cleaner, petroleum tank cleaner, asbestos abatement cleaner, and oil drilling fluid. It is also commonly used as an aerosol ingredient, fragrance ingredient, fragrance additive or odor mask in formulated products.

New applications for d-Limonene are emerging daily. d-Limonene is also showing promise in medical and pharmaceutical fields.

REGULATORY STATUS

d-Limonene has been designated as GRAS (Generally Recognized As Safe) by the Food and Drug Administration. The EPA has granted d-Limonene an exemption from the requirement of a tolerance when it is an inert ingredient used as a solvent or fragrance in pesticide formulations. d-Limonene is not considered a carcinogen, a developmental toxicant or mutagenic. d-Limonene is not listed on California Proposition 65.

d-Limonene is a naturally occurring VOC. d-Limonene is reportable on average as 95% VOC (850 grams per litre, 6.8 lbs per gallon). Emulsions containing d-Limonene can be exempt from VOC regulations. Contact state VOC or regulatory authorities for ruling.

PACKAGING

d-Limonene is packaged in phenolic-lined containers as follows:

<table>
<thead>
<tr>
<th>Container Size</th>
<th>Net Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Gallon Pail</td>
<td>7 Pounds Net Weight 3.2 kg Net Weight</td>
</tr>
<tr>
<td>5-Gallon Pail</td>
<td>35 Pounds Net Weight 16 kg Net Weight</td>
</tr>
<tr>
<td>55-Gallon Pail</td>
<td>390 Pounds Net Weight 177 kg Net Weight</td>
</tr>
</tbody>
</table>

Drums are typically orange or black DOT approved steel drums coated with a phenolic resin liner. All drums of our domestic d-Limonene are filled to a net weight of 390 lbs. Dimensions of 55-gallon drums are: length 23", width 23", and depth 35". Imported drums of Brazilian d-Limonene vary slightly in net weight – weight should be verified when ordering. Tank truck shipments average 6500 gallons (45,000 lbs). Overseas ISO tank shipments are either 20,000 liters (16,800 kg) or 24,000 liters (20,180 kg). Sample quantities (gallons & pints) are packaged in fluorinated plastic containers or glass (1 oz. samples).

STORAGE & HANDLING

Store in a warehouse with a fire prevention system. Avoid contact with incompatible chemicals listed in Section IV. Store in tightly sealed full containers in well-ventilated controlled warehouse conditions. Partially filled containers should be blanketed with nitrogen. Antioxidants such as BHT are commonly used in addition to proper storage and handling procedures.

Improper storage and handling can lead to oxidation.

d-Limonene samples and certificates of analysis are available upon request. Caution: The user should conduct his/her own experiments and establish proper procedures and controls before attempting use on critical parts.
FLORIDA CHEMICAL CO INC
251 Winter Haven Blvd., N.E.
Winter Haven, FL 33881-9432 USA
Ph: 863/294-8434 Fax: 863/294-7783
Email: info@floridachemical.com
Website: www.floridachemical.com

MATERIAL SAFETY DATA SHEET

d-Limonene
Technical, Food, and Lemon-Lime Grades

Emergency Phone Numbers:
Florida Chemical: (863) 294-8434
CHEMTRENC 24 Hour Number (800) 424-9300
Outside United States: Call CHEMTRENC Collect

November 2004

Section I - IDENTIFICATION

Trade Name: d-Limonene – Technical grade, Food grade, High Purity grades, Lemon-Lime grade, Orange Terpenes, Citrus Terpenes
Product Codes: 301000 - Technical Grade, 301000 - Citrus Terpenes, 302000 - Orange Terpenes, 302000 - Food Grade
CAS Number: 94-20-6 - Technical grade, 94-20-6 - Citrus Terpenes, 94-20-6 - Orange Terpenes
EINECS Nos: 232-433-8 - Food grade, 232-433-8 - Orange Terpenes
Synonyms: Citrus Stripper Oil, Terpene Hydrocarbons

Section II - HAZARDOUS COMPONENTS

Volatile Ingredients: d-Limonene (solvent) is the major component (technical grade >93%, food grade 95%, high purity grades >98%, lemon-lime 70%) with the balance consisting of other terpene hydrocarbons and oxygenated compounds - octanal, myrcene, alpha-pinene, limonol predominant. Product is a by-product of citrus, entirely of natural origin, and to the best of our knowledge contains no artificial flavors, sulfites, nitrates, or pesticide residue exceeding tolerances established by the FDA. d-Limonene does NOT contain lead, cadmium, mercury, or hexavalent chromium or come in contact with these chemicals since it is an citrus-derived essential oil produced by steam/vacuum distillation. Further, d-Limonene is packaged in food grade containers with inert liners that do NOT contain lead, cadmium, mercury, or hexavalent chromium. d-Limonene does NOT contain and is NOT manufactured with any of the Class I or II ozone-depleting substances listed under the United States Clean Air Act of 1990.

Hazardous Materials Identification System - HMIS:
1. Health Hazard - Mild skin irritant
2. Flammability - Flashpoint above 110° F (43° C)
0. Reactivity - Stable
G. Protection - Safety glasses, gloves

This substance contains no materials subject to the reporting requirements of SARA TITLE III SECTION 313.

Section III - PHYSICAL DATA

<table>
<thead>
<tr>
<th>Appearance</th>
<th>Technical Grade</th>
<th>Food Grade &amp; High Purity</th>
<th>Lemon-Lime Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor</td>
<td>Water-white oil</td>
<td>Water-white oil</td>
<td>Water-white oil</td>
</tr>
<tr>
<td>Specific Gravity (25°C)</td>
<td>0.838 - 0.843</td>
<td>0.838 - 0.843</td>
<td>0.941 - 0.948</td>
</tr>
<tr>
<td>Refractive Index (20°C)</td>
<td>1.4710 - 1.4740</td>
<td>1.4710 - 1.4740</td>
<td>1.470 - 1.4770</td>
</tr>
<tr>
<td>Flashpoint (CCCP)</td>
<td>&gt;110° F (43°C)</td>
<td>&gt;110° F (43°C)</td>
<td>&gt;110° F (43°C)</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>349°F (178°C)</td>
<td>349°F (178°C)</td>
<td>349°F (178°C)</td>
</tr>
<tr>
<td>Evaporation Rate</td>
<td>0.2 (BuAc=1)</td>
<td>0.2 (BuAc=1)</td>
<td>0.2 (BuAc=1)</td>
</tr>
<tr>
<td>Water Solubility</td>
<td>Insoluble</td>
<td>Insoluble</td>
<td>Insoluble</td>
</tr>
<tr>
<td>Vapor Pressure (20°C)</td>
<td>&lt;2mmHg</td>
<td>&lt;2mmHg</td>
<td>&lt;2mmHg</td>
</tr>
<tr>
<td>Melting Point Info</td>
<td>The published melting point of d-Limonene is approximately -140°F (-98°C). But, testing has shown that below -108°F (-78°C), it becomes a thick, white, gel-like substance that is impossible to pump.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Florida Chemical Co Inc
251 Winter Haven Blvd., N.E.
Winter Haven, FL 33881-9432 USA
Ph: 863/294-8434 Fax: 863/294-7783
Email: info@floridachemical.com
Website: www.floridachemical.com
Material Safety Data Sheet (cont.)

d-Limonene – all grades

Section IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point (CCPFP): >110°F (43°C)
Flammable Limits: LEL = 0.7% UEL = 6.1% (identified for Technical Grade only)
Extinguishing Media: Carbon dioxide, foam or dry chemical
Special Fire Fighting Procedures: SCBA recommended. Smother to exclude air. Do not use water. Handle as an oil fire.
Unusual Fire and Explosive Hazards: Combustible liquid. Keep away from heat, sparks, and open flame. Guard against spontaneous combustion of improperly discarded oily rags.
Incompatibility (Materials to avoid): Strong oxidizing agents and acidic agents including acidic clays, peroxides, halogens, vinyl chloride, and iodine pentafluoride.
Hazardous Decomposition Materials: Smoke may be acrid and the fumes may be irritating. Burning generates CO, CO₂, and smoke.

Hazardous Polymerization: None described
Conditions to Avoid for Polymerization: Polymerization catalysts such as aluminum chloride and acidic clays.
Stability Considerations: Stable
Conditions to Avoid for Stability: Avoid temperatures over 110° F (43°C)

Section V - HEALTH HAZARD DATA

Health Hazards (Acute and Chronic): Product is harmful if swallowed. Ingestion may cause vomiting, headache, and other medical problems. May be irritating to skin and eyes. Skin contact may cause slight redness. Eye contact can cause moderate to high irritation. Inhalation can cause nose, throat, and respiratory tract irritation, coughing and headache. Prolonged or repeated exposure can cause drying, defatting, and dermatitis of skin.
Signs and Symptoms of Exposure: Product may be irritating to the skin, eyes, nose and throat.
Medical Conditions Generally Aggravated by Exposure: Persons with allergies or pre-existing skin conditions should avoid contact with this product.

Emergency & First Aid Procedures:
Eyes: Remove contact lenses at once. Flush with water for at least 15 minutes. If irritation persists, seek medical attention.
Skin: Wash affected area with copious amounts of soap and water. If irritation develops, seek medical attention.
Ingestion: Seek medical attention immediately. Do not induce vomiting. Rinse mouth with water, then drink one glass of water. Do not leave victim unattended. Never give anything by mouth if victim is unconscious, is rapidly losing consciousness, or is convulsing.
Inhalation: If symptoms of overexposure are experienced, evacuate to fresh air. If symptoms persist, seek medical attention.

Section VI - TOXICOLOGICAL DATA/ACUTE TOXICOLOGY

d-Limonene is not acutely toxic.

Oral: LD₅₀ >5 g/kg, rabbit
Dermal: LD₅₀ >5 g/kg, rabbit
Skin: The skin irritancy of limonene in guinea pigs and rabbits is considered moderate and low, respectively.
Sensitization: d-Limonene is not a sensitizer. Improper storage and handling can lead to oxidation. The oxidized forms of d-Limonene have been shown to be a skin sensitizer.
Inhalation: RD₅₀ >1000 ppm

Ecotoxicological Information: Product may be toxic to aquatic organisms.

Section VII - SPILL OR LEAK PROCEDURES

Steps to be Taken if Material is Released or Spilled: Use protective gloves to avoid skin contact. Small spills can be wiped up. Large spills should be absorbed by dirt, sand, or other suitable absorbents for disposal. Do not hose spills down drains, sewers, or waterways. d-Limonene may be toxic to aquatic organisms. Move leaking containers to well ventilated area. No smoking. Eliminate any source of ignition. Minimize inhalation. Use NIOSH approved respiratory protection device in areas of high vapor concentration. CAUTION: slippery on floor.

Waste Disposal Method: Incinerate or Dispose in Accordance with Local, State, and Federal Regulations. Taking regulations into consideration, waste may be incinerated or handled through EPA spill control plan via landfill or dilution.
Material Safety Data Sheet (cont.)
d-Limonene – all grades

Section VIII - SPECIAL PROTECTION INFORMATION
Respiratory Protection: Not normally required. If vapor concentration becomes high, use NIOSH approved respirators.
Ventilation: Local exhaust should be adequate. Mechanical ventilation recommended as necessary.
Eye Protection: Safety goggles or glasses suggested.
Skin Protection: Oil resistant gloves.
Other Protective Equipment: Oil resistant apron, emergency eye wash and shower stations.
Appropriate Hygienic Practices: Wash thoroughly after handling. Launder contaminated clothing before re-use.

Section IX - SPECIAL PRECAUTIONS
Precautions to be taken in Handling and Storing: Usual precautions for combustible liquids.
Handling and Storage Precautions: Store in a warehouse with proper sprinkler/fire deterrent system. Avoid contact with incompatible chemicals listed in Section IV. Store in tightly sealed, full containers in well-ventilated controlled warehouse conditions. Partially filled containers should be blanketed with nitrogen.
Other Precautions: Product may expand slightly in storage causing pressure to build in container. Open container carefully if product appears to be under pressure. Drum lining may occasionally chip and fall to bottom of container after long storage or excessive handling. As a precaution, pour liquid through filter/strainer to catch small pieces of liner before blending or repackaging. Commerically clean empty containers before re-use. CAUTION: Do not weld or cut empty containers (Vapors May Ignite).

Section X - REGULATORY INFORMATION
Inventory

<table>
<thead>
<tr>
<th>Status</th>
<th>United States (TSCA)</th>
<th>Listed on the inventory.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Canada (DSL)</td>
<td>Listed on the inventory.</td>
</tr>
<tr>
<td></td>
<td>European Union (EINECS)</td>
<td>Listed on the inventory.</td>
</tr>
<tr>
<td></td>
<td>Australia (AICS)</td>
<td>Listed on the inventory.</td>
</tr>
<tr>
<td></td>
<td>Japan (MITI)</td>
<td>Listed on the inventory.</td>
</tr>
<tr>
<td></td>
<td>South Korea (KECL)</td>
<td>Listed on the inventory.</td>
</tr>
<tr>
<td></td>
<td>Philippines (PICCS)</td>
<td>Listed on the inventory.</td>
</tr>
</tbody>
</table>

Section XI - TRANSPORTATION INFORMATION

<table>
<thead>
<tr>
<th>DOT Label/Placard</th>
<th>Traffic Symbol applicable: Hazardous</th>
<th>Highway/Rail per requirements for Combustible Liquids</th>
<th>Air/Ship per requirements for Flammable Liquids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hazardous</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>Hazardous</td>
<td>A</td>
<td>B</td>
</tr>
</tbody>
</table>

SHIPPING CLASSIFICATION

Proper Shipping Name: TERPENE HYDROCARBONS, N.O.S.
Hazard Class: 3
Identification No.: UN2319
Packing Group: III

The listed Transportation Classification does not address regulatory variations due to changes in package size, mode of shipment or other regulatory descriptors.

Section XII - ADDITIONAL INFORMATION

National Fire Protection Association Hazard Ratings - NFPA(R):

1 Health Hazard - Slight
2 Flammability - Moderate
0 Reactivity - Minimal

Key Legend Information:
ACGIH American Conference of Governmental Industrial Hygienists
OSHA Occupational Safety and Health Administration
NTP National Toxicology Program
IARC International Agency for Research on Cancer

MSDS of Krud Kutter Original

MATERIAL SAFETY DATA SHEET
ORIGIHAL KRUD KUTTER

HAZARD RATINGS
NFPA HMIS DATA
HEALTH 1 0= MINIMAL
2=LIGHT
3=MED 1ATE
4=HIGH
5=EXtREME

SECTION I
MANUFACTURED BY:
SUPREME CHEMICALS OF GEORGIA, INC.
1555 Oak Industrial Lane, Suite D
Cumming, GA 30041
(800) 355-2976 CHEMTEK for EMERGENCY ONLY
(770) 495-7155
June 21, 2000
CLIFFORD M. CANTRELL

SECTION II HAZARDOUS INGREDIENTS/INFORMATION

<table>
<thead>
<tr>
<th>INGREDIENT</th>
<th>CAS NO.</th>
<th>OSHA PEL. TWA</th>
<th>ACLH TWA</th>
<th>OTHER STEL</th>
<th>% OR ING</th>
<th>S K</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-BUTOXETHANOL</td>
<td>11-75-3</td>
<td>20 PPM</td>
<td>10 PPM</td>
<td>50 PPM</td>
<td>&lt; 1</td>
<td>X</td>
</tr>
<tr>
<td>ETHANOL, 2-AMINO</td>
<td>141-48-5</td>
<td>2 mg/m³</td>
<td>2 mg/m³</td>
<td>8 mg/m³</td>
<td>&lt; 0.1</td>
<td>X</td>
</tr>
<tr>
<td>POTASSIUM HYDROXIDE</td>
<td>1310-58-3</td>
<td>3 PPM</td>
<td>2 PPM</td>
<td>5 PPM</td>
<td>&lt; 2</td>
<td>X</td>
</tr>
</tbody>
</table>

NOTE: An 'X' UNDER 'SKIN' INDICATES THAT OSHA RECOMMENDS SKIN PROTECTION TO PREVENT OR REDUCE EXPOSURE TO THIS INGREDIENT. ETHANOL, 2-AMINO AND 2-BTroxETHANOL ARE CLASS TITLE III, SECTION 5.13 SUBSTANCES WHICH MAY BE SUBJECT TO REPORTING BY manufacturing AND USERS.

EPA HAZARDOUS CATEGORIES
ACUTE HEALTH - CHRONIC HEALTH

SECTION III - PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point: 212°F Specific Gravity (H₂O=1) 1.01 - 1.02
Vapor Pressure (mm Hg) 17 Melting Point < 50°F
Vapor Density (Air=1) 3.2 Evaporation Rate (Water=1) < 1
Solubility in Water: Complete
Appearance and odor: Clear liquid with mild odor.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point (Method Used): None
Flammable Limits: LEL: 2.5%, UEL: N/A
Extinguishing Media: Carbon dioxide, dry chemical, alcohol foam, water fog
Special Fire Fighting Procedures: Firefighters should wear self-contained breathing apparatus and full protective clothing when fighting fires involving this product. Know known.
Unusual Fire and Explosion Hazards: None

SECTION V - REACTIVITY DATA

Stability: Stable
Incompatibility (Materials to Avoid): Do not mix with alkalis or oxidizing agents.
Hazardous Decomposition or Byproducts: Heat and carbon dioxide
Hazardous Polymerization: Will Not Occur
MATERIAL SAFETY DATA SHEET
ORIGINAL KRUD KUTTER

SECTION VI - HEALTH HAZARD DATA

Route(s) of Entry: Inhilation? Yes Skin? Yes Ingestion? Yes Eyes? Yes
Health Hazards (Acute and Chronic): None known.
Carcinogenicity:

NTP: Not listed.
IARC Monographs?: Not listed.
OSHA Regulated?: Not listed.

Signs and Symptoms of Exposure:
INHALATION: Irritation of respiratory system with possible difficulty in breathing.
INGESTION: Small amounts may cause nausea, vomiting, diarrhea and vomiting.
SKIN CONTACT: Possible irritation. Concentrated material may be absorbed through skin.
EYE CONTACT: Irritation and burning sensation with possible corneal damage.

Emergency and First Aid Procedures:
INGESTION: Give 2-4 glasses of water. Do not administer fluids to an unconscious person. Do not induce vomiting. GET MEDICAL ATTENTION IMMEDIATELY.
INHALATION: Remove victim to fresh air. If breathing does not return to normal, GET MEDICAL ATTENTION.
SKIN CONTACT: flush with clean running water for at least 15 minutes. If irritation results and persists, GET MEDICAL ATTENTION.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE

Steps to be Taken in Case Material Is Released or Spilled:
SMALL SPILLS: Plop to contain spillage.
LARGE SPILLS: Site to avoid spreading. Transfer to sealable containers for disposal at an approved hazardous waste site. Rinse spill area with water. Report any releases to ground or surface waters.

Waste Disposal Method: Convey wastes to federal, state, and locally approved hazardous waste disposal facility for neutralization.

Precautions to Be Taken in Handling and Storage: Do not mix with strong oxidizing reagents.

Other Precautions: KEEP THIS AND ALL CHEMICALS OUT OF REACH OF CHILDREN.

SECTION VIII - CONTROL MEASURES

Respiratory Protection (Specify Type): For use in enclosed areas, when spraying or when concentration in air exceeds limits see SECTION II. Use NIOSH/MSHA approved CBRN or better respirator.

Ventilation: GENERAL EXHAUST AS REQUIRED TO MAINTAIN CONCENTRATION BELOW PEL.

Protective Gloves: Rubber or neoprene.

Eye Protection: Chemical goggles recommended when using any chemical.

Other Protective Clothing or Equipment: As required to reduce or prevent skin contact. Wash contaminated clothing before reuse.

Work/Handling Practices: Wash product from clothes and skin. Use good housekeeping practices.

SECTION IX - ADDITIONAL INFORMATION

ENVIRONMENTAL

BIODEGRADABILITY: BIODEGRADABLE.

WASTE DISPOSAL METHODS: DISPOSE OF IN AN AUTHORIZED WASTE FACILITY IN ACCORDANCE WITH LOCAL, STATE, AND FEDERAL REGULATIONS.

ADDITIONAL INFORMATION

EMPTY CONTAINER HANDLING: WARNING! EMPTIED CONTAINER RETAINS PRODUCT RESIDUE. OBSERVE ALL PRECAUTIONS EVEN AFTER CONTAINER ISempt. KEEP EMPTY CONTAINER CLOSED TIGHTLY.

Page 2 of 3
MATERIAL SAFETY DATA SHEET
ORIGINAL KRUD KUTTER

SARA TITLE III REPORTING REQUIREMENTS

SECTION 302: EXTREMELY HAZARDOUS SUBSTANCES
SECTION 304: HAZARDOUS RELEASES
SECTION 311: COMMUNITY RIGHT TO KNOW (R-T-K)
SECTION 312: R-T-K INVENTORY DATA
SECTION 313: EMISSIONS AND RELEASE
CERCLA

REPORTING NOT REQUIRED
REPORTING NOT REQUIRED
REPORTING REQUIRED FOR INVENTORY ABOVE TQL
REPORTING REQUIRED FOR INVENTORY ABOVE TQL
REPORTING MAY BE REQUIRED FOR
MANUFACTURING SECTOR USERS
SAME AS SECTION 304

REFERENCES

TOXIC SUBSTANCE CONTROL ACT LIST (TSCA) - INGREDIENTS LISTED.

PERMISSIBLE EXPOSURE REFERENCES:

REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES
TITLE 29 CODE OF FEDERAL REGULATIONS
NATIONAL TOXICOLOGY PROGRAM (NTP) REPORT ON CARCINOGENS
INTERNATIONAL AGENCY FOR RESEARCH ON CANCER (IARC) MONOGRAPHS

REGULATORY STANDARDS:

DOT TITLE 49 CODE OF FEDERAL REGULATIONS 172.101
SARA TITLE III
NUCLEAR REGULATORY AGENCY


THE INFORMATION CONTAINED HEREIN is believed to be accurate but is not warranted to be so. Users are advised to confirm in advance of need that information is current, applicable and suited to the circumstances of use. Vendor assumes no responsibility for injury to vendor or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Furthermore, vendor assumes no responsibility for injury caused by abnormal use of this material even if reasonable safety procedures are followed.

MSDS of New II

!! This is a PROPRIETARY Record!!

Safety Information

FSC: 6850
NHN: 01–474–2317
MSDS Date: 03/02/2000
MSDS Name: CLHFN
Submitter: D DG
Tech Review: 07/27/2001
Status CD: A

Product ID: MFN:

NEW II (MIL–PRF–680, TYPE II) ENVIRONMENTALLY PREFERRED PART

Article: N
Kit Part: N

Cage: 0WU71

Responsible Party: ECOLINK INC

Address:
1481 ROCK MOUNTAIN BLVD

City: STONE MOUNTAIN
State: GA
Zip: 30083–1505

Country: US

Info Phone Number: 800–886–8240/770–621–8240

Emergency Phone Number: 800–535–5053

Proprietary Ind: Y

Review Ind: Y

Published: Y
Special Project CD: 

Summary

Cage: 0WU71

Address: ECOLINK INC
1481 ROCK MOUNTAIN BLVD

City: STONE MOUNTAIN
State: GA
Zip: 30083–1505

Country: US


SP0450–01–M–ZP27

Description Information
Item Manager: S9G

Item Name: CLEANING COMPOUND, SOLVENT

Specification Number: N/K Type/Grade/Class: N/K

Unit of Issue: CO Quantitative Expression: 00000000005GL

UI Container Qty: 000000005GL Type of Container: CONTAINER

<table>
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<tr>
<th>Ingredient</th>
<th>Cas: 64712-48-9</th>
<th>M</th>
<th>X</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Code:</td>
<td>RTECS #:</td>
<td>Code:</td>
</tr>
</tbody>
</table>

Name: ISOPARAFFINIC HYDROCARBON

% Text: N/P Environmental Wt:

OSHA PEL:

100 PPM Code: M OSHA N/P STEL: Code:

ACGIH TLV: N/P Code: ACGIH N/P STEL: Code:

EPA Rpt Qty:

DOT Rpt Qty:

Ozone-Depleting Chemical:

N

Hazard Data

<table>
<thead>
<tr>
<th>LD50 LC50</th>
<th>ORAL TOXICITY (MIC) – LD50 = 5 G/KG</th>
</tr>
</thead>
</table>

Route Of Entry Inds – Inhalation: YES Skin: YES Ingestion: YES

Carcinogenicity Inds – NTP: NO IARC: NO OSHA: NO

Health Hazards Acute And Chronic

Explanation Of Carcinogenicity

NO DATA PROVIDED BY MANUFACTURER

Signs And Symptoms Of Overexposure


Medical Cond Aggravated By Exposure

MAY AGGRAVATE PRE-EXISTING DISEASES OF THE SKIN, LIVER, KIDNEY AND RESPIRATORY SYSTEM.

First Aid

INGESTION: IF SWALLOWED, SEEK MEDICAL ATTENTION IMMEDIATELY. ONLY INDUCE VOMITING AT THE INSTRUCTION OF A PHYSICIAN. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON. INHALATION: REMOVE TO FRESH AIR. IF NOT BREATHING, PERFORM ARTIFICIAL RESPIRATION AND SEEK MEDICAL ATTENTION IMMEDIATELY. OXYGEN SHOULD ONLY BE ADMINISTERED BY TRAINED PERSONNEL. EYE: IRRIGATE IMMEDIATELY WITH WATER FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION IF IRRITATION PERSISTS. SKIN: WASH WITH SOAP AND WATER, THOROUGHLY CLEAN CONTAMINATED CLOTHING AND SHOES BEFORE REUSE. IF SYMPTOMS PERSIST, SEEK MEDICAL ATTENTION.

Spill Release Procedures

SMALL: ABSORB LIQUID WITH ABSORBENT MATERIAL, THEN PLACE IN A CHEMICAL WASTE CONTAINER. LARGE: ELIMINATE ALL IGNITION SOURCES (PLUGS, FLAMES INCLUDING PILOT LIGHTS, ELECTRICAL SPARKS). PERSONS NOT WEARING PROTECTIVE EQUIPMENT SHOULD BE EXCLUDED FROM AREA OF SPILL UNTIL CLEAN UP HAS BEEN COMPLETED. STOP SPILL AT SOURCE, PREVENT FROM ENTERING DRAINS, SEWERS, STREAMS, ETC. DIKE TO PREVENT LIQUID TRAVEL.

Neutralizing Agent

NO DATA PROVIDED BY MANUFACTURER

Waste Disposal Methods

NEW III IS TO BE DISPOSED OF ACCORDING TO LOCAL, STATE AND FEDERAL REGULATIONS. PLEASE CALL US IF YOU NEED ADDITIONAL DISPOSAL INFORMATION.

Handling And Storage Precautions

SINCE EMPTY CONTAINERS RETAIN PRODUCT RESIDUES, ALL HAZARD PRECAUTIONS GIVEN IN THE DATA SHEET MUST BE OBSERVED. ALL METAL PAILS OR DRUMS SHOULD BE GROUNDED & OR BUNDED WHEN MATERIAL IS TRANSFERRED.

Other Precautions
ANY USE OF THIS PRODUCT IN ELEVATED TEMPERATURE PROCESSES SHOULD BE THOROUGHLY EVALUATED TO ENSURE SAFE OPERATING CONDITIONS. SUDDEN RELEASE OF HOT ORGANIC CHEMICAL VAPORS WILL LEAD TO MISTS FROM PROCESS EQUIPMENT OPERATING AT ELEVATED TEMPERATURES MAY RESULT IN IGNITION. KEEP OUT OF REACH OF CHILDREN.

**Flash Point Method:**

TCC

**Flash Point:** ~62.8°C, 145°F  
**Flash Point Text:** BULK LIQUID

**Autoignition Temp:**  
**Autoignition Temp Text:** N/P

**Lower Limits:** 0.6  
**Upper Limits:** 6.5

**Extinguishing Media**

WATER SPRAY, DRY CHEMICAL OR ALCOHOL-COMPATIBLE FOAM IS RECOMMENDED.

**Fire Fighting Procedures**

COOL EXPOSED EQUIPMENT WITH WATER SPRAY UNTIL WELL AFTER FIRE IS OUT. FIRE FIGHTERS SHOULD WEAR SCBA WITH A FULL FACEPIECE OPERATED IN THE POSITIVE PRESSURE DEMAND MODE WITH APPROPRIATE GEAR AND CHEMICAL RESISTANT PERSONAL PROTECTIVE EQUIPMENT.

**Unusual Fire/Explosion Hazard**

VAPORS ARE HEAVIER THAN AIR AND MAY TRAVEL ALONG THE GROUND OR BE MOVED BY VENTILATION AND IGNITED BY HEAT, PILOT LIGHTS, OTHER FLAMES AND IGNITION SOURCES AT LOCATIONS DISTANT FROM MATERIAL HANDLING POINT. NEVER USE WELDING OR CUTTING TORCH ON OR NEAR DRUM (EVEN EMPTY) BECAUSE PRODUCT CAN IGNITE EXPLOSIVELY.

**Respiratory Protection**

USE NIOSH CERTIFIED ORGANIC VAPOR AIR PURIFYING RESPIRATOR, SELF-CONTAINED BREATHING APPARATUS, OR AIR-SUPPLIED RESPIRATORS DEPENDENT ON CONCENTRATION.

**Ventilation**

LOCAL EXHAUST HOOD OR FAN MAY BE USED. MECHANICAL VENTILATION MAY BE NECESSARY IF WORKING WITH THIS PRODUCT IN ENCLOSED AREA OR ELEVATED TEMPERATURES.

**Protective Gloves**

NITRILE GLOVES ARE RECOMMENDED FOR EXTENDED EXPOSURE OR IMMERSION OF HANDS.

**Eye Protection**
SAFETY GLASSES AND SPLASH PROTECTION REQUIRED.

Other Protective Equipment

NONE REQUIRED UNDER NORMAL USE. RUBBER GLOVES MAY BE USED FOR INCIDENTAL CONTACT.

Work Hygienic Practices

WE RECOMMEND THAT ALL RAGS USED TO ABSORB HYDROCARBON-BASED SOLVENTS BE DISPOSED OF IN AN AIRTIGHT METAL CONTAINER. TREAT THIS CHEMICAL WITH RESPECT AND FOLLOW MSDS INSTRUCTIONS.

Supplemental Safety and Health

BECAUSE IT IS A HYDROCARBON, IT SHOULD NOT BE SPRAYED IN A NON-CONTROLLED ENVIRONMENT, OR MISTED IN SUCH A WAY THAT IT COULD BE INHALED.

<table>
<thead>
<tr>
<th>Physical Chemical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC: V4</td>
</tr>
<tr>
<td>NRC State LIC No: N/R</td>
</tr>
</tbody>
</table>

Net Prop WT For Ammono:

- Boiling Point: -187.8°C, 370°F
- Melt/Freeze Pt: <-51.1°C, -60°F
- Decomp Temp: N/P
- Vapor Pres: 0.44 x 10^4
- Vapor Density: 5–6
- Volatile Org Content %: Spec Gravity: 0.767
- VOC Pounds/Gallon: PH: N/P
- VOC Grams/Liter: Viscosity: N/P

Evaporation Rate & Reference:

- Solubility in Water: N/P

Appearance and Odor: SAYBOLT COLOR +30; ODORLESS

Percent Volatiles by Volume: 100%
Corrosion Rate: N/P
Stability Indicator:  
YES

Stability Condition To Avoid: HIGH TEMPERATURES.

Materials To Avoid: STRONG OXIDIZING AGENTS AND/OR STRONG ACIDS.

Hazardous Decomposition Products: NONE EXPECTED.

Hazardous Polymerization Indicator: NO

Conditions To Avoid Polymerization: NONE.

Toxicological Information:

SKIN TOXICITY: ABSORPTION (RABBITS) – LD50 = 2.0–4.0 G/KG.

Ecological Information:

NO DATA PROVIDED BY MANUFACTURER

Transport Information:


Regulatory Information:

CERCLA (SUPERFUND): NOT APPLICABLE.

Federal Regulatory Information: RCRA REGULATED: NO. ALL MATERIALS IN PRODUCT ARE TSCA LISTED.

State Regulatory Information: NO DATA PROVIDED BY MANUFACTURER.

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MSDS of N-methyl pyrrolidone (NMP)

SECTION 1: IDENTIFICATION

Product Name: N METHYL PYRROLIDONE
Product Number: 00000000000499183
Internal ID: 187
Chemical Family: Cyclic Amide
CAS Number: 872-50-4
Chemical Name: N-Methyl-2-pyrrolidinone
Synonyms: 2-Pyrrolidinone, 1-methyl-, N-Methyl-2-pyrrolidinone, NMP
Type of Use: Solvent.

Manufacturer
Lyondell Chemie Nederland, B.V.
Weena Point D, Weena 762
3014 DA Rotterdam The Netherlands

Business Contact
Service Centre Europe 31 (0) 10 275 55 00
24 Hour Emergency Contact
Service Centre Europe 31 (0) 10 275 57 77

SECTION 2 : COMPOSITION/INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>Component Name</th>
<th>CAS #</th>
<th>EU Inventory</th>
<th>Concentration Wt.%*</th>
<th>Risk</th>
<th>Symbol</th>
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</thead>
<tbody>
<tr>
<td>N-Methyl-2-pyrrolidinone</td>
<td>872-50-4</td>
<td>212-828-1</td>
<td>&lt;= 99.9</td>
<td>R36/38</td>
<td>Xi</td>
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</table>

* Concentration of gaseous products or materials is given in Mole %
Compositions given are typical values not specifications.

SECTION 3: HAZARD IDENTIFICATION

Emergency Overview

Hazards
Irritant.

R-Phrases
R36/38 - Irritating to eyes and skin.

Physical State
Liquid.

Color
Clear, colorless to slightly yellow.

Odor
Amine-like odor.

Odor Threshold
No Data Available.
Potential Health Effects

Routes of Exposure
SKIN: Eye: Inhalation

Signs and Symptoms of Acute Exposure
See component summary.

- N-Methyl-2-pyrrolidinone 872-50-4
  Moderate to severe eye irritant. Mildly irritating to the skin but not a skin sensitizer. Skin absorption hazard. Inhalation irritation. Irritating to gastrointestinal tract.

Skin
Skin absorption hazard. Mildly irritating to the skin but not a skin sensitizer.

Inhalation
Signs of respiratory tract irritation (such as nasal discharge and difficulty breathing) may occur after exposure to aerosol or high vapor concentrations.

Eye
Moderate to severe eye irritant. Excess redness of the conjunctiva may occur. Permanent corneal damage is not expected.

Ingestion
Ingestion may cause discomfort and irritation of the gastrointestinal tract, dizziness and shortness of breath.

Chronic Health Effects
See component summary.

- N-Methyl-2-pyrrolidinone 872-50-4
  Repeated inhalation exposure may cause reversible irritation at the site of initial contact, and transient CNS effects have also been observed. NMP produced liver tumors and kidney effects in test animals. The relevance of these findings to humans is unknown. NMP may adversely affect reproduction in the rat after ingestion, although fertility is unaltered. The relevance of these findings to humans is unknown. Fetal effects were seen in pregnant animals exposed to NMP by ingestion, inhalation and skin contact. The relevance of these findings to humans is unknown.

Conditions Aggravated by Exposure
This material or its emissions may defat skin, cause contact dermatitis, or otherwise aggravate existing skin disease.

SECTION 4: FIRST AID MEASURES

General
Take proper precautions to ensure your own health and safety before attempting rescue and providing first aid. For specific information refer to the Emergency Overview in Section 3 of this MSDS.

Skin
Immediately remove contaminated clothing. Wash skin thoroughly with mild soap and water. Flush with lukewarm water for 15 minutes. If sticky, use waterless cleaner first. Seek medical attention if ill effect or irritation develops.

Inhalation
If overcome by exposure, remove victim to fresh air immediately. Give oxygen or artificial respiration as needed. Obtain emergency medical attention. Prompt action is essential.

Eye
Thoroughly flush the eyes with large amounts of clean low-pressure water for at least 15 minutes, occasionally lifting the upper and lower eyelids. If irritation persists, seek medical attention.

Ingestion
N METHYL PYRROLIDONE

If large quantity swallowed, give lukewarm water (pint/ 1/2 litre) if victim completely conscious/alert. Do not induce vomiting. Risk of damage to lungs exceeds poisoning risk. Obtain emergency medical attention.

Note to Physician
Treat symptomatically. Treatment of overexposure should be directed at the control of symptoms and the clinical condition of the patient.

SECTION 5: FIRE FIGHTING MEASURES

Flammable Properties
Classification
Combustible liquid.

Flash Point:
86 °C (186.8 °F) (Closed Cup)
95 °C (203 °F) (Open Cup)

Auto-Ignition Temperature
~ 270 °C (518 °F)

Lower Flammable Limit
~ 1.3 vol%

Upper Flammable Limit
~ 0.5 vol%

Extinguishing Media
Suitable: SMALL FIRE: Use dry chemical, CO2, water spray or regular foam. LARGE FIRE: Use water spray, water fog or regular foam. Do not use straight streams.

Unsuitable: No additional information available.

Protection of Firefighters
Protective Equipment/Clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Structural firefighters protective clothing will only provide limited protection.

Fire Fighting Guidance: When heated above the flash point, releases flammable vapors. When mixed with air and exposed to ignition source, vapors can burn in open or explode if confined. Vapors may be heavier than air. May travel long distances along the ground before igniting and flashing back to vapor source. Fine sprays/ mist may be combustible at temperatures below normal flash point. Move containers from fire area if you can do it without risk. Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. Always stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Hazardous Combustion Products: Incomplete combustion may produce carbon monoxide, oxides or compounds of nitrogen and other toxic gases.

SECTION 6: ACCIDENTAL RELEASE MEASURES

Release Response
Combustible liquid. Eliminate all sources of ignition. All equipment used when handling this product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Use clean non-sparking tools to collect absorbed material. Dike large spills and place materials in salvage containers. Water spray may reduce vapor, but may not prevent
ignition in closed spaces.

SECTION 7: HANDLING AND STORAGE

Handling
Handle empty containers with care - residue may be combustible and burn if exposed to heat/sparks/open flame. In addition to the fire/explosion hazard, residual vapor and liquid may also be toxic. Keep container tightly closed when not in use. Keep away from heat, sparks, open flames, or any ignition source. Isolate, vent, drain, wash and purge systems or equipment before maintenance or repair. Wear recommended personal protective equipment. Observe precautions pertaining to confined space entry.

Storage
Mild or stainless steel. Store away from heat, sparks, open flames, strong oxidizing agents and direct sunlight.

SECTION 8: EXPOSURE CONTROLS AND PERSONAL PROTECTION

Engineering Controls
At elevated temperatures, special ventilation may be required even if the flash point has not been exceeded. Flammable mists or aerosols can be generated below the flash point of high boiling liquids.

Personal Protection
Inhalation: If exposure can potentially exceed the exposure limit(s), respiratory protection recommended or approved by appropriate local, state or international agency must be used.

Skin: Wear chemical resistant gloves such as Butyl rubber. When skin contact is possible, protective clothing including gloves, apron, sleeves, boots, head and face protection should be worn. The equipment must be cleaned thoroughly after each use.

Eye: Eye protection, including both chemical splash goggles and face shield, must be worn when possibility exists for eye contact due to splashing/spaying liquid, airborne particles, or vapor.

Additional Remarks
Selection of appropriate personal protective equipment should be based on an evaluation of the performance characteristics of the protective equipment relative to the task(s) to be performed, conditions present, duration of use, and the hazards and/or potential hazards that may be encountered during use. Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure. Use good personal hygiene practices. Wash hands before eating, drinking, smoking, or using toilet facilities. Promptly remove soiled clothing/wash thoroughly before reuse.

Occupational Exposure Limits

<table>
<thead>
<tr>
<th>Component Name</th>
<th>Source / Date</th>
<th>Value</th>
<th>Type</th>
<th>Notation</th>
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<tbody>
<tr>
<td>N-Methyl-2-pyrrolidone</td>
<td>US (ACGIH)</td>
<td>NIL</td>
<td></td>
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</tr>
<tr>
<td>MAK (AT)</td>
<td>20 ppm</td>
<td>8 HRS/TWA</td>
<td>Skin.</td>
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<td></td>
</tr>
<tr>
<td>ELV (FI)</td>
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<td>8 HRS/TWA</td>
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<tr>
<td>ELV (IE)</td>
<td>25 ppm</td>
<td>8 HRS/TWA</td>
<td>Skin.</td>
<td></td>
</tr>
<tr>
<td>MAC (NL)</td>
<td>20 ppm</td>
<td>8 HRS/TWA</td>
<td>No</td>
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</table>
## N METHYL PYRROLIDONE

<table>
<thead>
<tr>
<th>ELV (NO)</th>
<th>5 ppm</th>
<th>8 HRS/TWA</th>
<th>Skin.</th>
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</thead>
<tbody>
<tr>
<td>VLA (ES)</td>
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<td>TLV (SE)</td>
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<td>SUVA (CH)</td>
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</tr>
<tr>
<td>HSE (UK)</td>
<td>75 ppm</td>
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<td>Skin.</td>
</tr>
</tbody>
</table>

### SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

**Appearance:** Liquid. Clear, colorless to slightly yellow.

**Odor:** Amine-like odor.

**Odor Threshold:** No Data Available.

**pH:** 7 - 8

**Boiling Point/Boiling Range:** 202 °C (395.6 °F) @ 760 mm Hg

**Freezing Point/Melting Point:** -25.0 °C (-13 °F)

**Flash Point:** 86 °C (186.8 °F) (Closed Cup) 95 °C (203 °F) (Open Cup)

**Auto-ignition:** ~ 270 °C (518 °F)

**Flammability:** Combustible liquid.

**Lower Flammable Limit:** ~ 1.3 vol%

**Upper Flammable Limit:** ~ 9.5 vol%

**Explosive Properties:** No Data Available.

**Oxidizing Properties:** No Data Available.

**Vapor Pressure:** < 0.3 mm Hg @ 20 °C (68 °F)

**Evaporation Rate:** ~ 0.03 (butyl acetate = 1)

**Relative Density:** ~ 1.03 @ 25 °C (77 °F) (Water = 1.0 at 4 °C (39.2 °F))

**Relative Vapor Density:** ~ 3.4 @ 15.5 - 32.2 °C (59.9 - 89.96 °F) (Air = 1.0)

**Viscosity:** No Data Available.

**Solubility (Water):** Complete (in All Proportions).

**Partition Coefficient (Kow):** Log Kow = -0.54
Material Safety Data Sheet

N METHYL PYRROLIDONE

Additional Physical and Chemical Properties: Hygroscopic. Additional properties may be listed in Sections 3 and 5.

SECTION 10: STABILITY AND REACTIVITY

Chemical Stability
Stable.

Conditions to Avoid
Severe reducing conditions. In contact with moisture, this hygroscopic (i.e., absorbs water from the air) material may degrade or become contaminated. Heat, sparks, open flame, other ignition sources, and oxidizing conditions.

Substances to Avoid
Severe oxidizing conditions.

Decomposition Products
Carbon monoxide and nitrogen oxide fumes emitted when heated to decomposition.

Hazardous Polymerization
Not expected to occur.

Reactions with Air and Water
Not expected to occur.

SECTION 11: TOXICOLOGICAL INFORMATION

PRODUCT INFORMATION

Product Summary
N-methyl pyrrolidone (NMP) is of slight acute toxicity. Liquid NMP is a moderate to severe eye irritant and mildly irritating to skin but is not a skin sensitizer. It is readily absorbed after ingestion, inhalation and skin contact. Repeated inhalation exposure may cause reversible irritation at the site of initial contact, and transient CNS effects have also been observed. Repeated long term ingestion was associated with an increased severity of spontaneous progressive nephropathy in male rats, and increased liver weight and increased hepatic cell hypertrophy in male and female mice. It is not genotoxic in vitro or in vivo. No increase in tumors was seen in rats exposed by inhalation or via feed for two years, however an increase in liver tumors was noted in mice over a similar period. The relevance of these findings to humans appears doubtful, however, since liver tumors are commonly reported when non-genotoxic chemicals are tested in the mouse bioassay. Adverse effects on reproduction have been reported in rats after ingestion of amounts of NMP which also caused mild generalized changes in the parental animals. Fetal effects have been noted in pregnant animals exposed by ingestion, inhalation and skin contact, and occurred both in the presence and absence of maternal toxicity.

COMPONENT INFORMATION

- N-Methyl-2-pyrrolidinone  872-59-4

<table>
<thead>
<tr>
<th>Acute Toxicity - Lethal Doses</th>
<th>Rat</th>
<th>LD50 (oral)</th>
<th>4150 MG/KG BWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD50 (skin)</td>
<td>Rat</td>
<td>7000 MG/KG BWT</td>
<td></td>
</tr>
</tbody>
</table>

Irritation

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N METHYL PYRROLIDONE

Skin: Contact may cause mild skin irritation.

Eye: Moderate to severe eye irritant.

Target Organ Effects

Reproductive Effects
NMP may adversely affect reproduction in the rat after ingestion, although fertility is unaltered. These effects occurred at exposures which also caused mild generalized effects in the parental animals. It is therefore unclear if NMP specifically targets the reproductive system or whether these changes were secondary to other systemic effects. The relevance of these findings to humans is unknown. Fetal effects (including delayed development and the occurrence of soft tissue and skeletal variations) were observed in pregnant animals exposed by ingestion, inhalation and skin contact. While these events generally occurred in the presence of maternal toxicity, mild fetotoxicity was sometimes present in the absence of maternal effects. The relevance of these findings to humans is unknown.

Carcinogenicity
No increase in tumors in rats exposed by inhalation or via feed for 2 years. A dietary study found increased liver tumors in male and female mice given 1100 and 1400 mg/kg bw/day for 18 months, respectively. Since liver tumors are commonly reported when non-genotoxic chemicals are tested in the mouse bioassay, the relevance of these findings to humans appears doubtful.

SECTION 12: ECOLOGICAL INFORMATION

PRODUCT INFORMATION

Ecotoxicity
This material is expected to be non-hazardous to aquatic species. See component summary.

WQK 1 (Slightly water-endangering)

Environmental Fate and Pathway
This material is not expected to persist in the environment. It is water soluble and is expected to have low volatility. It is expected to be poorly adsorbed onto soils or sediments. Hydrolysis is not expected to be an important factor in the environmental fate process for this material. See component summary.

COMPONENT INFORMATION

- N-Methyl-2-pyrrolidinone 872-50-4

Ecotoxicity
This material is expected to be non-hazardous to aquatic species.

Acute toxicity to fish
LC50 / 96 HOURS bluegill 8.32 mg/l
LC50 / 96 HOURS fathead minnow 1.072 mg/l
LC50 / 96 HOURS rainbow trout 3.048 mg/l
Acute toxicity to aquatic invertebrates
EC50 / 24 HOURS: Daphnia magna > 1,000 mg/l

Toxicity to aquatic plants
EC50 / 72 HOURS: Green algae (Scenedesmus subspicatus) > 500 mg/l

Environmental Fate and Pathway
This material is not expected to persist in the environment. It is water soluble and is expected to have low volatility. It is expected to be poorly adsorbed onto soils or sediments. Hydrolysis is not expected to be an important factor in the environmental fate process for this material.

Persistence and Degradability
Biodegradation: BOD (Modified MITI Method) = 73% (28 days). BOD (Modified MITI Method) = 92% (14 days). This material is expected to be readily biodegradable.

Bioaccumulation: BCF = 0.16. This material is not expected to bioaccumulate.

SECTION 13: DISPOSAL CONSIDERATIONS
Contaminated product, soil, water, container residues and spill cleanup materials may be hazardous wastes. Comply with applicable local, state or international regulations concerning solid or hazardous waste disposal and/or container disposal.

SECTION 14: TRANSPORT INFORMATION

Special Requirements
If you reformulate or further process this material, you should consider re-evaluation of the regulatory status of the components listed in the composition section of this sheet, based on final composition of your product.

Proper Shipping Name N-METHYL-2-PYRROLIDONE

SECTION 15: REGULATORY INFORMATION

<table>
<thead>
<tr>
<th>Country</th>
<th>Inventory</th>
<th>X = All components are included or are otherwise exempt from inclusion on this inventory.</th>
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</thead>
<tbody>
<tr>
<td>Australia</td>
<td>AICS</td>
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<td>NDSL</td>
<td>X</td>
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<td>China</td>
<td>IECB</td>
<td>X</td>
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<td>FINCA</td>
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<td>ELINCS</td>
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<td>NLP</td>
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<tr>
<td>United States</td>
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</table>

Labeling Information
Symbol

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N METHYL PYRROLIDONE

Irritant.

R-Phrases
R36/38 - Irritating to eyes and skin.

S-Phrases
S41 - In case of fire and/or explosion, do not breathe fumes.

Other
EU Labeling Information:

SECTION 16: OTHER INFORMATION

Latest Revision(s)
Revised Section(s): 3 9 11 12 Date of Revision: February 13, 2003
Revised Section(s): 8 Date of Revision: April 1, 2004
Revised Section(s): 5 9 Date of Revision: August 31, 2004
Revised Section(s): 15 November 2004

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Numerical Data Presentation
The presentation of numerical data, such as that used for physical and chemical properties and toxicological values, is expressed using a comma (,) to separate digits into groups of three and a period (.) as the decimal marker. For example, 1,234.56 mg/kg = 1 234.56 mg/kg

Language Translations
The information presented in this document has been translated from English by a vendor Lyondell believes to be reliable. Lyondell and its vendor have made a good-faith effort to verify the accuracy of the translation, but assume no responsibility for any errors that may have occurred. Please refer to our web sites (www.lyondell.com and www.equistarchem.com) for the original document written in English.

< end of document >
MSDS of QED

Safety Information

FSC: 6850  NIN: 01-412-0620  MSDS Date: 10/24/1995  MSDS Name: BYGHC
Submitter: D DGI  Tech Review: 02/26/1996  Status CD: C
Product ID: QED ENVIRONMENTALLY PREFERRED SOLVENT, PART #0301  MFS: 01
Article: N  Kit Part: N

Responsible Party
Name: BOCOLINK INC
Address: 1481 ROCK MOUNTAIN BLVD
City: STONE MOUNTAIN  State: GA  Zip: 30083
Country: US
Info Phone Number: (800) 886-8240 OR 404-621-8240
Emergency Phone Number: 800-886-8240
Preparer's Name: N/P
Proprietary Ind: N  Review Ind: Y  Published: Y  Special Project CD: N

Summary
Name: BOCOLINK INC
Address: 1481 ROCK MOUNTAIN BLVD
City: STONE MOUNTAIN  State: GA  Zip: 30083-1505
Country: US
Phone: 800-886-8240 770-621-8240

Description Information

Item Manager: S9G

Item Name: CLEANING COMPOUND, SOLVENT
Specification Number: UNKNOWN  Type/Grade/Class: NK

Unit of Issue: CN  Quantitative Expression: 00000000006G
UJ Container Qty: 0  Type of Container: CAN

Ingredients

Name: MINERAL SPIRITS, (ALIPHATIC HYDROCARBON, LIGHT OIL DISTILLATE)

% Vol: >80  Environmental Wt:
Other RSC Limits: NO USE RECOMMENDED
OSHA PEL: NOT ESTABLISHED  OSHA STEL: Code: M
ACGIH TLV: NOT ESTABLISHED  N/P  Code: M
ACGIH
STEL:
DOT Rpt
QY:

Crane Dewatering Chemical: N

<table>
<thead>
<tr>
<th>Hazard Data</th>
<th>Health</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LD50 LC50 Missing: UNKNOWN

Route Of Entry Ind: Inhalation: YES, Skin: YES, Ingestion: YES
Carcinogenicity Ind: NTP: NO, IARC: NO, OSHA: NO

Health Hazards Acute And Chronic

INGRST CAN CAUSE GASTROINTESTINAL IRRITATION, NAUSEA, VOMITING, ASPIRATION INTO LUNGS MAY CAUSE INJURY, EXCESSIVE VAPOR INHALATION MAY CAUSE DIZZINESS OR HEADACHES. PRODUCT HAS LOW VAPOR PRESSURE & NOT DISTILLED TO PREVENT INHALATION. HAZARDS SHOWN SHOULD BE TAKEN TO PREVENT AEROSOLIZATION OR MISFILING WITHOUT TAKING SPECIFIC PRECAUTIONS.

Explanations Of Carcinogenicity

PER MSDS, CARCINOGEN NTP/IARC/OSHA: NONE.

Signs And Symptoms Of Overexposure

GASTROINTESTINAL IRRITATION, NAUSEA, VOMITING, ASPIRATION INTO LUNGS MAY CAUSE INJURY. DIZZINESS, HEADACHE, SLIGHT EYES IRRITATION, SKIN IRRITATION. EXCESSIVE DEHYDRATION AND FLAKING OF SKIN.

Medical Conditions Aggravated By Exposure

NONE SPECIFIED BY MANUFACTURER.

First Aid

INGRST DO NOT INDUCE VOMITING. PRODUCT CONTAINS HYDROCARBON. CALL PHYSICIAN. INHALATION. REMOVE TO FRESH AIR. BREATH DIFFICULT. GIVE OXYGEN. CALL PHYSICIAN. EYES: IRREGATE IMMEDIATELY. WASH WITH WATER. FOR RESPIRATORY FUELS CALL PHYSICIAN. SKIN: WASH OFF IN FLOWING WATER OR SHOWER USING SOAP OR WATER. REMOVE CONTAMINATED CLOTHING.

Spill Release Procedures

NOTIFY PROPER ENVIRONMENTAL PROFESSIONALS. REPLACE ALL IGNITION SOURCES. ABSORB LIQUID ON ABSORBENT MATERIAL. REMOVE ALL IGNITION SOURCES. EXTINGUISH PROPELLANT FIRE SCRUTINIZE DRAINAGE IN MANNER CONFORMING TO STATED SPILL PREVENTION PLAN. CALL RECYCLING FOR DISPOSAL ASSISTANCE.

Neutralizing Agent

NONE SPECIFIED BY MANUFACTURER.

Waste Disposal Methods

HAZ WASTE PROD: IGNITABLE. PROD CONTAMINATED W/ WATERO. CLEANING RESULTING Mixture MAY BE CONSIDERED HAZARDOUS. PERFORM APPROPRIATE HAZ WASTE DETECTION (TCP, FLASH POINT, IRRITABILITY) LACED IN MANNER CONFORMING TO STEPS SPILL PREVENTION PLAN.

Handling And Storage Precautions

TRASH AS COMBUSTIBLE LIQUID. WASH ANY COMBUSTIBLE SOLVENT IN TRASH. REPLACE IN CONJUNCTION WITH PRODUCT MUST BE PLACED IN METAL SEALABLE CONTAINER APT FOR USE TO AVOID SPONTANEOUS RECRISTALIZATION.

Other Precautions

OTHER INDUSTRIAL SOLVENTS, ENVIRONMENT-FRIENDLY. INTENDED TO REPLACE PRODUCTS MORE HAZARDOUS, SUCH AS TRICHLORETHANE, MINERAL SPIRITS, ETAL. NOT COMPLETELY HARMLESS. IRRITATION TO SKIN.
Explosion Hazard Information

Flash Point Method: TCC
Flash Point: N/A
Autoignition Temp: N/A
Lower Limits: NONE KNOWN
Upper Limits: NONE KNOWN
Extinguishing Media
REGULAR FOAM, CO₂, DRY CHEMICALS.

Fire Fighting Procedures
FIGHT AS HYDROCARBON FIRE. WEAR SELF-CONTAINED NIOSH APPROVED, BREATHING APPARATUS.

Unusual Fire/Explosion Hazard
NON-TOXIC & TOXIC FUMES MAY FORM UPON COMBUSTION. STAY UPWIND OF FIRE.

Measures
Respiratory Protection
NOT REQUIRED UNDER CONDITIONS OF NORMAL USE. IF VAPOR MIST IS GENERATED USE A NIOSH CERTIFIED ORGANIC VAPOR RESPIRATOR W/DUST & MIST FILTER.

Ventilation
LOCAL EXHAUST/HOOD OR FAN MAY BE USED. SET TO MAINTAIN BELOW TLV. MECHANICAL-NONE REQUIRED.

Protective Gloves
RUBBER GLOVES RECOMMENDED.

Eye Protection
SAFETY GLASSES ARE RECOMMENDED.

Other Protective Equipment
NONE REQUIRED.

Work Hygiene Practices
WASH CONTAMINATED CLOTHING BEFORE USE. USE W/ADEQUATE VENTILATION. WASH HANDS AFT USE.

Supplemental Safety and Health
HEALTH HAZ PRECAUTIONS, EYES: EXPO TO HIGH CONCEN OF VAP MAY CAUSE IRRITATION TO EYES. SKIN: PROLONGED REPEAT EXPO MAY CAUSE IRRITATION. REPEATED OR LONG-TERM CONTACT MAY CAUSE EXCESSIVE DRYING/PLAKING OF SKIN. STORAGE/HANDLING: KEEP CONTAINER CLSD. READ ALL HBl. INFO USE AVOID EXCESSIVE CONTACT W/FUMES/LIQ.

Physical/Chemical Properties

RCC: F4
NRC/State LIC No: N/R
Net Prop WT For Ammon.
Boiling Point: B.P. Temp: 320°F, 160°C
Melt/Freeze Pt: M.P./P. Temp: N/A
Decomp Temp: Decomposition: N/P
Vapor Press: <1 SPEC Gravty: 0.750
Vapor Density: >1
Volatile Org Cont.: FIH: N/P
VOC Pounds/Grade: Viscosity: N/P

Evaporation Rate & Reference:
Solubility in Water: NEGIGIBLE.
Appearance and Odor: CLEAR, COLORLESS LIQUID.

Percent Volatile by Volume: N/P
Corrosion Rate: N/P

Stability Indicator: YES
Stability Condition To Avoid: EXCESSIVE HAT.
Materials To Avoid: AVOID CONTACT W/STRONG OXIDIZING AGENTS.
Hazardous Decomposition Products: OXIDES OF CARBON MAY BE FORMED UPON
COMBUSTION.

Hazardous Polymerization Indicator: NO
Conditions To Avoid Polymerization: NOT APPLICABLE

Toxicological Information: N/P
Ecological Information: N/P
Transport Information: N/P
SARA Title III Information: N/P
Federal Regulatory Information: N/P
State Regulatory Information: N/P
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MATERIAL SAFETY DATA SHEET: SIMPLE GREEN®

also for : SIMPLE GREEN® SCRUBBING PAD

I. PRODUCT & COMPANY INFORMATION

PRODUCT NAME: SIMPLE GREEN® ALL-PURPOSE CLEANER
SIMPLE GREEN® CONCENTRATED CLEANER / DEGREASER / DEODORIZER
SIMPLE GREEN® SCRUBBING PAD

COMPANY NAME: SUNSHINE MAKERS, INC.
15922 Pacific Coast Highway
Huntington Harbour, CA 92649 USA
Telephone: 800-228-0705 • 562-795-6000
Fax: 562-592-3034
Website: www.simplegreen.com

For 24-hour emergency, call Chem-Tel, Inc.: 800-255-3924

USE OF PRODUCT: An all purpose cleaner and degreaser used diluted in water for direct, spray, and dip tank procedures. (Scribbled pad is used with water for manual scrubbing applications.)

II. INGREDIENT INFORMATION

The only ingredient of Simple Green® with established exposure limits is undiluted 2-butoxyethanol (<6%) (Butyl Cellosolve; CAS No. 111-76-2); the ACGIH TLV-TWA is 20 ppm (97 mg/m³).

Based upon chemical analysis, Simple Green® contains no known EPA priority pollutants, heavy metals, or chemicals listed under RCRA, CERCLA, or CWA. Analysis by TCLP (Toxicity Characteristic Leaching Procedure) according to RCRA revealed no toxic organic or inorganic constituents.

All components of Simple Green® are listed on the TSCA Chemical Substance Inventory.

III. HAZARDS IDENTIFICATION

UN Number: Not required
Dangerous Goods Class: Nonhazardous

Hazard Rating (NFPA/HMIS)
Health = 1* Reactivity = 0
Fire = 0 Special = 0

Rating Scale
0 = minimal 1 = slight
2 = moderate 3 = serious
4 = severe

*Nond eye irritant, non-mutagenic and non-carcinogenic. None of the ingredients in Simple Green® are regulated or listed as cancer agents by Federal OSHA, NTP, or IARC.
IV. FIRST AID MEASURES

SYMPTOMS OF OVEREXPOSURE AND FIRST AID TREATMENT

Eye contact: Reddening may develop. Immediately rinse the eye with large quantities of cool water; continue 10-15 minutes or until the material has been removed; be sure to remove contact lenses, if present, and to lift upper and lower lids during rinsing. Get medical attention if irritation persists.

Skin contact: Minimal effects, if any; rinse skin with water, rinse shoes and launder clothing before reuse. Reversible reddening may occur in some dermal-sensitive users; thoroughly rinse area and get medical attention if reaction persists.

Swallowing: Essentially non-toxic. Give several glasses of water to dilute; do not induce vomiting. If stomach upset occurs, consult physician.

Inhalation: Non-toxic. Exposures to concentrate-mist may cause mild irritation of nasal passages or throat; remove to fresh air. Get medical attention if irritation persists.

V. FIRE FIGHTING MEASURES

Simple Green® is stable, not flammable, and will not burn.

Flash Point/Auto-Ignition: Not flammable.

Flammability Limits: Not flammable.

Extinguishing Media: Not flammable/nonexplosive. No special procedures required.

Special Fire Fighting Procedures: None required.

VI. ACCIDENTAL RELEASE MEASURES

Recover usable material by convenient method; residual may be removed by wipe or wet mop. If necessary, unrecoverable material may be washed to drain with large quantities of water.

VII. HANDLING, STORAGE & TRANSPORT INFORMATION

No special precautions are required. This product is non-hazardous for storage and transport according to the U.S. Department of Transportation Regulations. Simple Green® requires no special labeling or placarding to meet U.S. Department of Transportation requirements.

UN Number: Not required

Dangerous Goods Class: Non-hazardous

VIII. EXPOSURE CONTROLS

Exposure Limits: The Simple Green® formulation presents no health hazards to the user when used according to label directions for its intended purposes. Mild skin and eye irritation is possible (please see Eye contact and Skin contact in Section IV).

Ventilation: No special ventilation is required during use.

Human Health Effects or Risks from Exposure: Adverse effects on human health are not expected from Simple Green®, based upon twenty years of use without reported adverse health incidence in diverse population groups, including extensive use by inmates of U.S. Federal prisons in cleaning operations.

Simple Green® is a mild eye irritant; mucous membranes may become irritated by concentrate-mist.

Simple Green® is not likely to irritate the skin in the majority of users. Repeated daily application to the skin without rinsing, or continuous contact of Simple Green® on the skin may lead to temporary, but reversible, irritation.

Medical Conditions Aggravated by Exposure: No aggravation of existing medical conditions is expected; dermal sensitive users may react to dermal contact by Simple Green®.
IX. PERSONAL PROTECTION

Precautionary Measures: No special requirements under normal use conditions.

Eye Protection: Caution, including reasonable eye protection, should always be used to avoid eye contact where splashing may occur.

Skin Protection: No special precautions required; rinse completely from skin after contact.

Respiratory Protection: No special precautions required.

Work and Hygienic Practices: No special requirements. Wash or rinse hands before touching eyes or contact lenses.

X. PHYSICAL AND CHEMICAL PROPERTIES

Appearance/odor: Translucent green liquid with characteristic sassafras odor. (Scrubber is green fibrous rectangle.)

Specific Gravity: 1.0257

Vapor Pressure: 17 mm Hg @ 20 °C; 22 mm Hg @ 25 °C

pH of Concentrate: 9.5

Vapor Density: 1.3 (air = 1)

Evaporation: >1 (butyl acetate = 1)

Density: 8.5 lbs/gallon

Boiling Point: 110 °C (231 °F)

Freezing Point: -9 °C (16 °F) If product freezes, it will reconstitute without loss of efficacy when brought back to room temperature and agitated.

VOC Composite Partial Pressure: 0.006 mm Hg @ 20 °C

Volatile Organic Compounds (VOCs): 7.96 g/L per ASTM Method 3960-90. Per EPA Method 24, VOCs are 5.9% and product must be diluted at least 1 part of water to 1 part Simple Green® in order to meet CARB 2005 VOC regulations — or 1 part Simple Green® to 3 parts water to meet SCAQMD Rule 1171 & Rule 1122 and BAAQMD Regulation 8-16 VOC requirements for solvent cleaning operations.

Water Solubility: Completely soluble in water. The higher salt concentrations in marine ecosystems will lead to complexes with Simple Green® that may become visible at ratios above one part Simple Green® to 99 parts seawater.

Ash Content: At 600 °F: 1.86% by weight.

Nutrient Content: Nitrogen: <1.0% by weight (fusion and qualitative test for ammonia);

Phosphorus: 0.3% by formula;

Sulfur: 0.8% by weight (barium chloride precipitation method);

Detection: Simple Green® has a characteristic sassafras odor that is not indicative of any hazardous situation.

XI. STABILITY AND REACTIVITY INFORMATION

Nonreactive. Simple Green® is stable, even under fire conditions, and will not react with water or oxidizers. Hazardous polymerization will not occur.

XII. TOXICOLOGICAL INFORMATION

Nonhuman Toxicity

Acute Mortality Studies: Oral LD₅₀ (rat) >5.0 g/kg body weight // Dermal LD₅₀ (rabbit): >2.0 g/kg body weight

Dermal Irritation: Only mild, but reversible, irritation was found in a standard 72-hr test on rabbits. A value of 0.2 (non-irritating) was found on a scale of 6.

Eye Irritation: With or without rinsing with water, the irritation scores in rabbits at 24 hours did not exceed 15 (mild irritant) on a scale of 110.

Subchronic dermal effects: No adverse effects, except reversible dermal irritation, were found in rabbits exposed to Simple Green® (up to 2.0 g/kg/day for 13 weeks) applied to the skin of 25 males and 25 females. Only female body weight gain was affected. Detailed microscopic examination of all major tissues showed no adverse changes.

Fertility Assessment by Continuous Breeding: The Simple Green® formulation had no adverse effect on fertility and reproduction in CD-1 mice with continuous administration for 18 weeks, and had no adverse effect on the reproductive performance of their offspring.
XIII. BIODEGRADABILITY AND ENVIRONMENTAL TOXICITY INFORMATION

Biodegradability:
Simple Green® is readily decomposed by naturally occurring microorganisms. The biological oxygen demand (BOD), as a percentage of the chemical oxygen demand (COD), after 4, 7, and 11 days was 50%, 60%, and 70%, respectively. Per OECD Closed Bottle Test, Simple Green® meets OECD and EPA recommendations for ready biodegradability. In a standard biodegradation test with soils from three different countries, Butyl Cellosolve reached 50% degradation in 6 to 23 days, depending upon soil type, and exceeded the rate of degradation for glucose which was used as a control for comparison.

Environmental Toxicity Information:
Simple Green® is considered practically non-toxic per EPA's aquatic toxicity scale. Simple Green® is non-lethal to any of the marine and estuarine test animals listed in the following table at concentrations below 200 mg/L (0.02%). This table shows the Simple Green® concentrations that are likely to be lethal to 50% of the exposed organisms.

<table>
<thead>
<tr>
<th>Marine Fish:</th>
<th>LC₅₀ in mg/L (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mud minnow (Fundulus heteroclitus)</td>
<td>1690 1574</td>
</tr>
<tr>
<td>Whitebait (Galaxias maculatus)</td>
<td>210 210</td>
</tr>
<tr>
<td>Marine/Estuarine Invertebrates:</td>
<td></td>
</tr>
<tr>
<td>Brine Shrimp (Artemia salina)</td>
<td>610 399</td>
</tr>
<tr>
<td>Grass Shrimp (Palaemonetes pugio)</td>
<td>270 220</td>
</tr>
<tr>
<td>Green-lipped Mussel (Perna canaliculus)</td>
<td>220 220</td>
</tr>
<tr>
<td>Mud Snail (Potamopyrgus estuarinus)</td>
<td>410 350</td>
</tr>
</tbody>
</table>

XIV. DISPOSAL CONSIDERATIONS

Simple Green® is fully water soluble and biodegradable and will not harm sewage-treatment microorganisms if disposal by sewer or drain is necessary. Dispose of in accordance with all applicable local, state, and federal laws.

XV. OTHER INFORMATION

Containers: Simple Green® residues can be completely removed by rinsing with water; the container may be recycled or applied to other uses.

Electrical Wiring Compatibility: Polymide insulated wiring is not affected by exposure to Simple Green®. After immersion in Simple Green® for 14 days at 74°F, the 0.1 cm piece of polymide insulated wire passed a one minute dielectric proof test at 2500 volts (ASTM D-149).

Contact Point: Sunshine Makers, Inc., Research and Development Division, 562-795-6000.

National Stock Numbers:

<table>
<thead>
<tr>
<th>PART#</th>
<th>NSN</th>
<th>SIZE</th>
<th>PART#</th>
<th>NSN</th>
<th>SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>13012</td>
<td>7900-01-542-5315</td>
<td>24 oz. spray (12 oz.)</td>
<td>13018</td>
<td>7900-01-342-5317</td>
<td>15 gal.</td>
</tr>
<tr>
<td>13005</td>
<td>7900-01-300-8360</td>
<td>1 gal. (60 oz.)</td>
<td>13008</td>
<td>7900-01-342-4145</td>
<td>55 gal.</td>
</tr>
<tr>
<td>13008</td>
<td>7900-01-342-5316</td>
<td>5 gal.</td>
<td></td>
<td>7900-01-345-9148</td>
<td>100 gal.</td>
</tr>
<tr>
<td></td>
<td>10224</td>
<td>roaring fork</td>
<td></td>
<td>10224</td>
<td>roaring fork</td>
</tr>
</tbody>
</table>

*** NOTICE ***

All information appearing herein is based upon data obtained by the manufacturer & recognized technical sources. Judgments as to the suitability of information herein for purchaser's purposes are necessarily purchaser's responsibility. Therefore, although reasonable care has been taken in the preparation of this information, Sunshine Makers, Inc. or its distributors extend no warranties, makes no representations and assumes no responsibility as to the suitability of such information for application to purchaser's intended purposes or for consequences of its use.

MSDS of Vortex ®

VORTEX
Organic, Semi-Aqueous Solvent
Product Data Sheet

Description
This blend of natural ingredients is a 100% organic formulation representing a completely new approach in one step degreasing. It is non-corrosive and contains no petroleum distillates, halogenated solvents or alkalins. This multi-purpose formulation will strip grease and heavy oil deposits from virtually any surface. It will emulsify instantly in water, at ambient temperature, to penetrate and liquefy many different types of resins and greases.

VORTEX is a perfect product for removing oily film of any kind from metal surfaces. VORTEX quickly removes even the toughest organic soils such as tar, asphalt and bitumen. VORTEX is the cleaner of choice for cleaning and degreasing virtually all surfaces without worker hazard or negative environmental impact.

Benefits
- Biodegradable
- No harmful fumes
- All natural ingredients
- No petroleum distillates
- No hazardous materials or listed solvents

Applications
This product is used undiluted and may be sprayed, wiped or mopped on. For accumulation of grease, tar and asphalt on engines, machine parts, etc., spray on to thoroughly wet surface. Allow 5 minutes contact time and hose off with water under pressure. For heavy accumulations use a wire brush to loosen grease and oil, then rinse.

Key Physical Characteristics

<table>
<thead>
<tr>
<th>Property</th>
<th>Typical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling Point</td>
<td>320° F</td>
</tr>
<tr>
<td>Color</td>
<td>Clear, Colorless Liquid</td>
</tr>
<tr>
<td>Evaporation Rate</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Odor</td>
<td>Mild Citrus Terpene</td>
</tr>
<tr>
<td>Solubility in Water</td>
<td>Emulsifiable</td>
</tr>
<tr>
<td>Specific Gravity (H2O=1)</td>
<td>0.844</td>
</tr>
<tr>
<td>Vapor Density</td>
<td>&gt; 1</td>
</tr>
<tr>
<td>Vapor Pressure (mm Hg)</td>
<td>&lt; 1 mm Hg @ 58° F</td>
</tr>
<tr>
<td>VOC Content</td>
<td>797 g/m³</td>
</tr>
</tbody>
</table>

Safety and Handling Precautions
Use adequate ventilation. Solvent resistant nitrile gloves are recommended. Safety glasses or splash goggles are recommended. Wash hands after use. Treat as simple oil waste. Incinerate or landfill in manner conforming to state, federal and local regs. All rags must be placed in a metal sealable container after use to avoid possible spontaneous combustion. Keep container closed. Keep out of reach of children. Treat this chemical with respect and follow all MSDS instructions.

Packaging

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Part No.</th>
<th>Packaging</th>
<th>National Stock No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VORTEX</td>
<td>0145-55</td>
<td>55 Gal Drum</td>
<td>6850-01-386-8434</td>
</tr>
<tr>
<td>VORTEX</td>
<td>0145-6</td>
<td>6 Gal Pail</td>
<td>6850-01-386-8404</td>
</tr>
<tr>
<td>VORTEX</td>
<td>0145-5</td>
<td>5 Gal Pail</td>
<td></td>
</tr>
<tr>
<td>VORTEX</td>
<td>0145-1</td>
<td>6 x 1 Gal Case</td>
<td>6860-01-366-9405</td>
</tr>
<tr>
<td>VORTEX</td>
<td>0145-1</td>
<td>4 x 1 Gal Case</td>
<td>6850-01-366-9405</td>
</tr>
</tbody>
</table>
Material Safety Data Sheet

VOXRTX
Maximum Performance
Organic Solvent
Rev. 01/25/2000

Section I: Product Identification
Product name: VOXRTX
Synonym: Organic Solvent
Molecular Formula: Proprietary Blend

The "Plain English" Section
Material Safety Data Sheets can be confusing. Federal law requires us to print a great deal of technical information, which probably won't help the non-scientist. ECOLINK includes this "PLAIN ENGLISH" section, written to address the questions and concerns of the average person. If you have additional health, safety or product questions, don't hesitate to call us at 800/888-8240.

Health Hazards: VOXRTX is an industrial chemical. We call it "environmentally preferred" because it is intended to replace products that are more hazardous. (1,1,1-tribromononane, mineral spirits, MEK, etc.). This does not mean that VOXRTX is completely harmless. It is strong enough to remove tough industrial soils, so it can irritate your skin. We suggest you wear gloves, and avoid extended exposure to unprotected skin. Don't get it in your eyes, or breath large amounts of the vapor. If you do, seek medical assistance. Used on a rag or from a spray bottle, the product won't produce fumes in any great quantity, (don't spray VOXRTX under high pressure without adequate ventilation).

For more exposure and first aid information, refer to MSDS sections II, VI.

Flashpoint: VOXRTX's flashpoint is 124°F. This represents the temperature that the liquid must reach before it emits fumes that will ignite. This is pretty hot, so combustion in ordinary use isn't a big concern. If VOXRTX is used on rags, the rags can ignite if exposed to an open flame because the solvent is "wicked" onto the cloth. Be sure to dispose of rags in an airtight container specifically designed to prevent spontaneous combustion. Don't use VOXRTX or any other combustible solvent around welding or any other hot work area.

Disposal: Because VOXRTX's flashpoint is below 140°F, VOXRTX is considered a hazardous waste product, (ignitable). If you spill VOXRTX, notify the proper environmental or safety department at your company ASAP. Once VOXRTX is contaminated with whatever you are cleaning, the resulting mixture may fall under an additional hazardous classification, depending on whether or not the material you are cleaning is hazardous. If you are not sure how to dispose of the used VOXRTX give us a call and we will help you make the right decision.

Section II: Chemical or Hazardous Components
Chemical Name: Citrus Terpene
CAS No.: 88847-72-3
Approx. wt. %: 95%
Exposure: *MRL - 100 ppm
OSHA-PEL - N/E

* Manufacturer's Recommended Exposure Limit

Chemical Name: Nonylphenoxyn
Polyethoxyethanol
CAS No.: 9016-45-9
Approx. wt. %: 5%
Exposure: ACGIH-TLV - 100 ppm
OSHA-PEL - N/E

Exposure limits are based upon the ACGIH recommendation for components of the same chemical family.

RCRA REGULATED: Yes (Refer to Sec. VIII)
CERCLA (Superfund): N/A
ALL MATERIALS IN PRODUCT ARE TSCA LISTED.

(Containers less than 110 gallons)
DOT Regulated: No
DOT Haz. Class: N/A
DOT Shipping Name: N/A
DOT Number: Not listed

(DOT information: refer to DOT manual CFR 49, Chapter 1, 1098 edition)

Section III: Physical Data
Appearance & Odor: Clear, colorless liquid with mild citrus terpene odor.
Boiling Point: 320°F @ 760 mm Hg
Evaporation Rate: <1
Specific Gravity (H2O=1): 0.844
Solubility In Water: Emulsifiable
VOC Content: 797 g/m²
Vapor Pressure (psia): 1.0 mm Hg
Vapor Density (AIR=1): >1
Section IV: Fire and Explosion Hazard Data

Flash Point (Method): Bulk Liquid (TDC) , 124°F

Flammable Limits:
LEL 0.7
UEL 6.1

Autoignition temperature (minimum temperature required to initiate self-sustained combustion in the absence of a spark or flame): 302°F

Extinguishing Media:
Regular foam, water fog, carbon dioxide, dry chemical, class B.

Special Fire Fighting Procedures:
Keep fire exposed containers cool with water. Fire fighters should wear self-contained breathing apparatus with a full facepiece operated in the positive pressure demand mode with appropriate gear and chemical resistant personal protective equipment.

Unusual Fire & Explosion Hazards:
Vapors are heavier than air and may travel along the ground or be moved by ventilation and ignited by heat, pilot lights, other flames and ignition sources at locations distant from material handling point. Never use welding or cutting torch on or near drum (even empty) because product can ignite explosively.

Section V: Reactivity Data

Stability: Stable

Conditions to Avoid:
Sources of ignition such as sparks, hot spots, welding, flames and cigarettes. Ignition/flash may result if concentration of product is in the flammable range (See Section IV for LEL and UEL values).

Incompatibility (materials to avoid):
If mixed with strong oxidizers or acids there is the possibility of a dangerous chemical reaction.

Hazardous Decomposition:
May form carbon dioxide and carbon monoxide.

Hazardous Polymerization:
Will Not Occur.

Section VI: Health Hazard Data

Primary routes of exposure: Oral, Inhalation, and Skin

Ingestion:
Swallowing large amounts may be harmful by causing gastrointestinal irritation.

Inhalation:
Breathing large amounts may be harmful by causing nose, throat, respiratory tract irritation.

Eyes:
Irritant. Liquid contact will irritate eyes and may cause stinging, burning, and redness.

Skin or Contact:
May cause mild irritation or redness and burning, skin defatting.

First Aid:

Ingestion:
Do not induce vomiting. If conscious, give 1 or 2 glasses of water. Seek medical attention immediately. Place individual on left side with head down. Caution: aspiration into lungs can cause chemical pneumonitis.

Inhalation:
Remove to fresh air, if breathing is difficult give oxygen. Keep person warm and quiet. Seek medical attention.

Eyes:
Irrigate immediately with water for at least 15 minutes. Get medical attention if irritation persists.

Skin:
Wash with soap and water. Thoroughly clean contaminated clothes and shoes before re-use. If symptoms persist, seek medical attention.

Cardiogenic:
NTP – Not Listed
IARC Monographs – None
OSHA REGS – Not Regulated

Section VII: Precautions for Safe Handling

HMIS Information:
Health – 1 / Flammability – 2 / Reactivity – 0

Personal Protection – B

HMIS Definition:
0 – Minimal 1 – Slight 2 – Moderate 3 – Serious 4 – Extreme
*“” in the Health Category denotes material does not target any major organs.
*** In the Health Category denotes material may target certain organs.

Eye Protection:
Safety glasses and splash protection required.

Protective Gloves:
Nitrile gloves.

Respiratory Protection:
Not required under conditions of normal use. If vapor mist is present use NIOSH certified organic vapor mask.

Ventilation:
Local exhaust or fan may be used.

Other Protective Clothing:
Not required under normal use.

Work Practices:
Store rags used with this material in an air tight, metal container to prevent spontaneous combustion. Treat this chemical with respect and follow all MSDS Instructions.

Section VIII: Control Measures

Small Spill:
Absorb liquid on vermiculite, floor absorbent, or other absorbent material and transfer to hood.

Large Spill:
Eliminate all ignition sources, (flares, flames including pilot lights, electrical sparks). Persons not wearing protective equipment should be excluded from area of spill until clean up has been completed. Stop spill...
Section IX: Part Number and Packaging

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Part No.</th>
<th>Packaging</th>
<th>National Stock No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vortex</td>
<td>0145-55</td>
<td>55 Gal. Drum</td>
<td>6850-01-388-8434</td>
</tr>
<tr>
<td>Vortex</td>
<td>0145-5</td>
<td>5 Gal. Pail</td>
<td></td>
</tr>
<tr>
<td>Vortex</td>
<td>0145-6</td>
<td>6 Gal. Pail</td>
<td>6850-01-388-8404</td>
</tr>
<tr>
<td>Vortex</td>
<td>0145-1</td>
<td>6 x 1 Gal. Case</td>
<td>6850-01-388-8405</td>
</tr>
<tr>
<td>Vortex</td>
<td>0145-1</td>
<td>4 x 1 Gal. Case</td>
<td></td>
</tr>
</tbody>
</table>

DISCLAIMER: Ecolink, Inc. believes the information contained herein is accurate. However, Ecolink makes no warranty, expressed or implied, regarding the accuracy of this data or the results to be obtained by the use thereof. Ecolink, Inc. assumes no responsibility for injury from the use of the product described herein.

END OF MSDS