The Modular Asteroid Chip Sampler (MACS) Tool

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1) Technical Overview

1.1) Nomenclature

NASA - National Aeronautics and Space Administration
ISS - Illinois Space Society
NExT - Neutral Buoyancy Experiment Design Team
MACS Tool - Modular Asteroid Chip Sampler Tool
EVA - Extra-Vehicular Activity
CAD - Computer Aided Design
FEA - Finite Element Analysis
COTS - Commercial Off The Shelf
ABS - Acrylonitrile Butadiene Styrene
LRRG - Linear Ratchet Rack Gear
NBL - Neutral Buoyancy Laboratory
SEDS - Students for the Exploration and Development of Space
STEM - Science, Technology, Engineering, and Math

1.2) Test Week Preference

1. June 6-9, 2016
2. May 23-25, 2016
3. April 25-28, 2016

1.3) Advisor/Mentor Request

The Illinois Space Society (ISS) Micro-g NExT team will be requesting a NASA JSC advisor for future assistance and mentorship throughout the competition process.

1.4) Abstract

From the Apollo program to the International Space Station, manned space missions have always been a challenging yet inspiring foundation upon which future progress has been built. In the near future, manned missions to the surface of asteroids will be essential to the exploration objectives at NASA. Not only will asteroid missions provide information about our vast universe, but they will also serve as an ideal test bed for future manned deep-space missions. The effectiveness of manned missions and the associated extra-vehicular activities (EVA) relies on the development of innovative EVA sample collection tools. The Micro-g NExT Rock-Chip Sampling Device challenge intends to gain a better understanding of how astronaut-conducted sample

collection in microgravity environments can be made more efficient, reliable, and intuitive. The Modular Asteroid Chip Sampler Tool (MACS) developed by the Illinois Space Society Micro-g team seeks to provide a solution for this exact problem. The MACS Tool is a purely mechanical system that uses a hand-cranked spring mechanism to drive a chisel-bit into the surface of an asteroid. The force from the tool impacting the surface will produce a chip sample that will be directed to a modular canister that will then detach from the tip of the tool and then safely stowed in a collection bag. The MACS Tool will utilize four separate modular containers to allow for sample collection at multiple sites without cross contamination. Using a combination of machined metal and 3D printed components, the MACS Tool will be an appropriate balance of rapid production and testing with structural robustness.

1.5) Test Objectives

1.5.1) Technical Design

The driving requirement of the design methodology was to keep the tool user-friendly, intuitive, and modular. The MACS Tool is a compact, ambidextrous, spring driven rock chip sampler. The tool utilizes 4 individual, detachable pods to allow for sample collection and containment at 4 unique sights. Depending on the preference of the astronaut, the tool can be configured for left or right hand primary operation prior to simulated experiments. This is accomplished by attaching a ratcheting handle to the preferred side of the tool body. The ratcheting handle allows for astronauts to load the spring through their desired range of motion. This will require little suit mobility to prepare the MACS Tool for sample collection at the mining sight. A view of the MACS Tool in both left and right hand preferred configurations is shown below in Figure 1-1 and Figure 1-2 respectively.

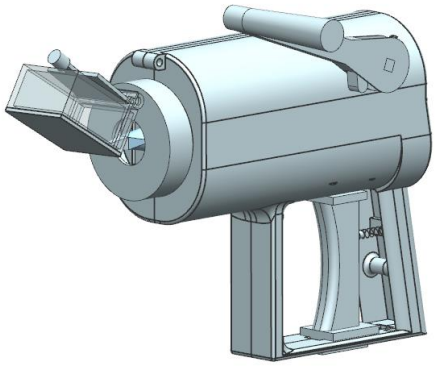

Figure 1-1: MACS-Tool Full Assembly Left-Hand Configuration

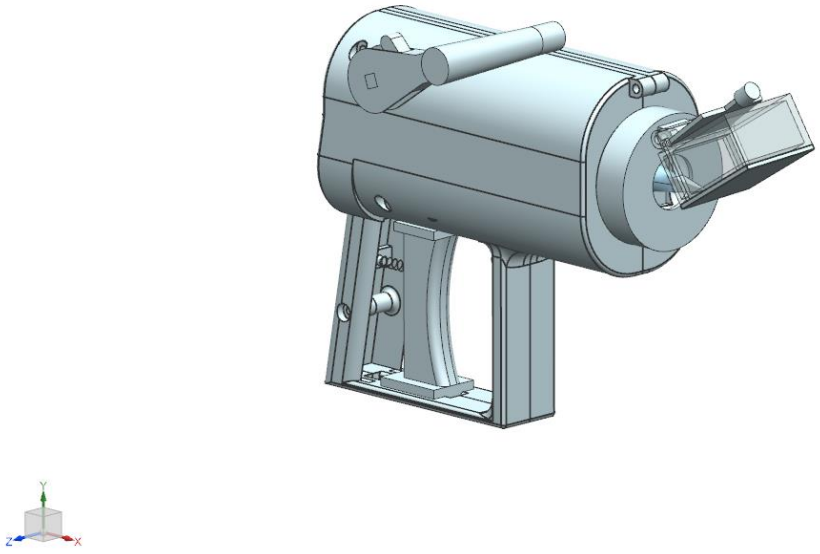

Figure 1-2: MACS-Tool Full Assembly Right-Hand Configuration

The ratchet handle compresses the spring by using a gear/gear-rack system within the body of the tool. As the handle is rotated forward, the attached gear will retract a gear rack integrated to the chisel frame. The trigger is a spring-activated ratchet and pawl system that will provide a quick release of the gear rack, propelling the compressed spring and chisel into the surface of the sample. The trigger and pawl will be connected using a cable. The inner gear and spring systems can be seen below in Figure 1-3:

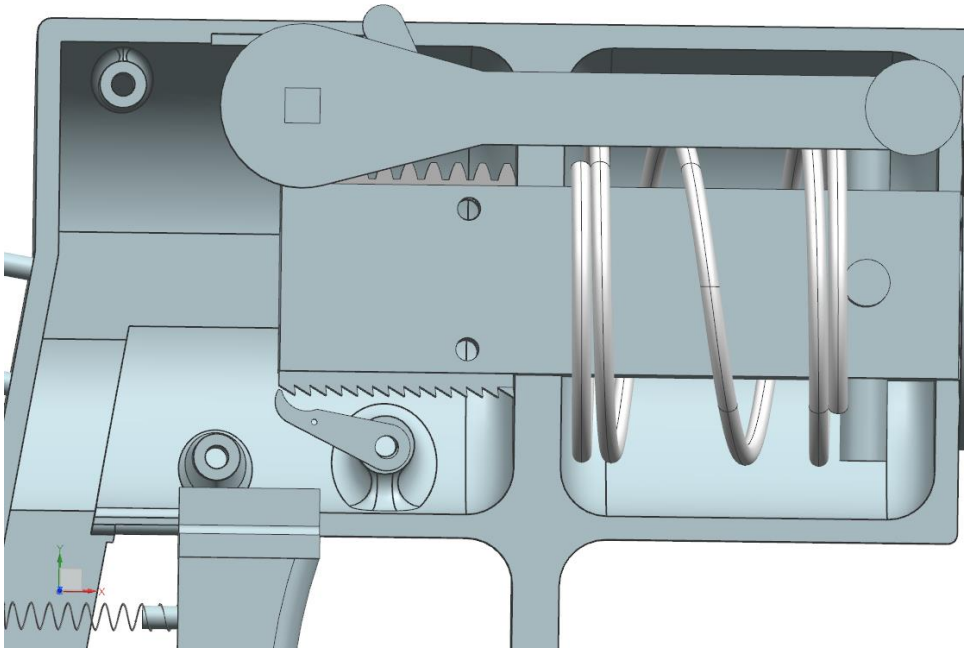

Figure 1-3: Compression Spring Assembly

The firing mechanism is released by pressing a spring-regulated trigger connected to the pawl on the underside of the main gear rack. A trigger safety will be implemented such that astronauts cannot activate the trigger without specifically deactivating the safety mechanism.The trigger and pawl will be connected by a high tensile-strength, braided Kevlar cord. The trigger was designed to be pressed by all the fingers of the astronauts' gloved hand or simply by a finger. These options allow the astronaut to pull the trigger in a comfortable manner without needing a lot of dexterity from the glove. A close up view of the trigger-pawl system can be seen below in Figure 1-4:

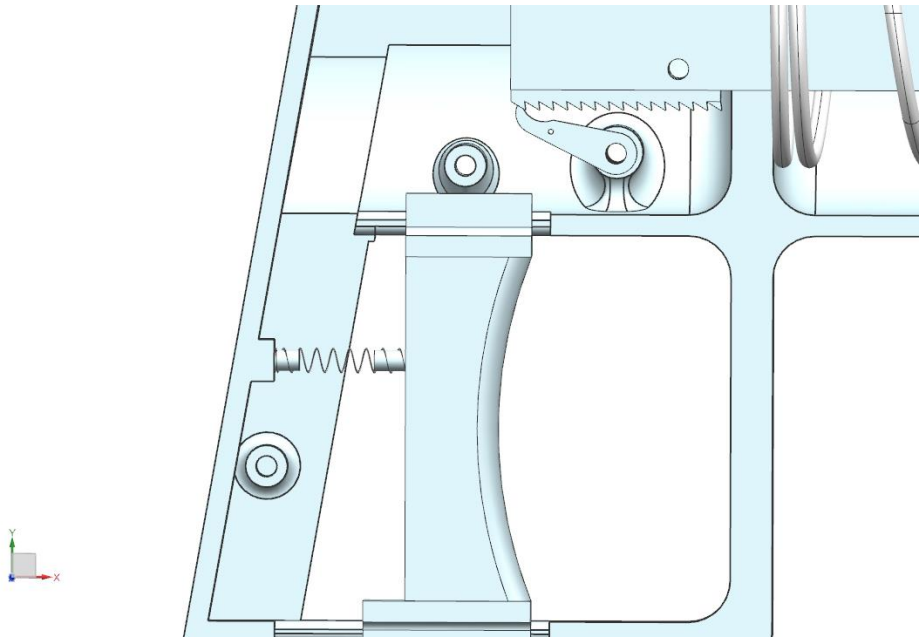

Figure 1-4: Trigger and Pawl Assembly

The spring-driven chisel is designed to strike the sample surface and deflect rock chips into the sample collection pods. The sample collection pods are acrylic containers that are attached to the forward end of the tool. This is done by guiding a stud on the collection pod through a predetermined path. The pods will have a rotating slide door system that will ensure sample integrity when travelling to and from sample sites. Storage of the sample pods is achieved by detaching the used pod from the forward attachment, and reattaching either to a picatinny rail on the side of the tool body or to a collection bag carried by the astronaut (for extra samples). Views of the collection pod and its attachment mechanism are shown below in Figure 1-5:

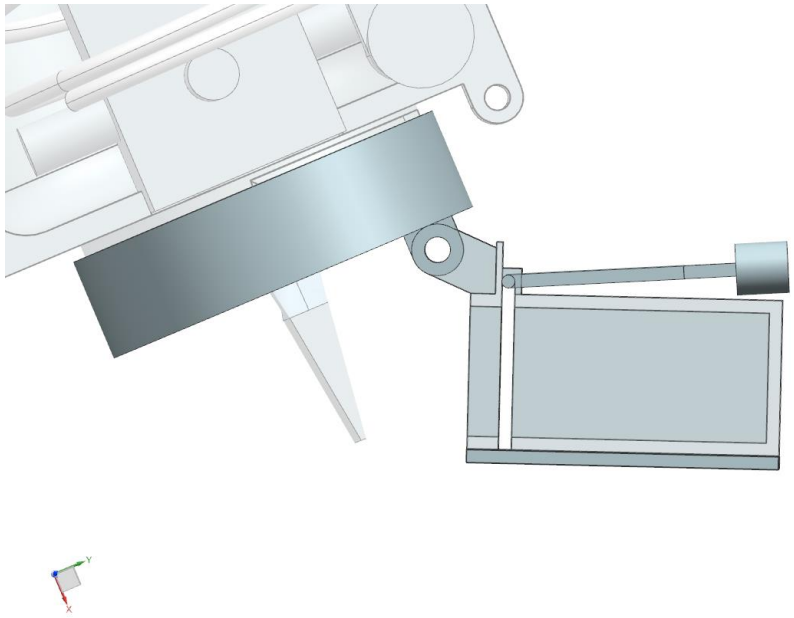

Figure 1-5: Collection Pod Assembly

A photo demonstration of the sample pod collecting and securing a sample is demonstrated below.

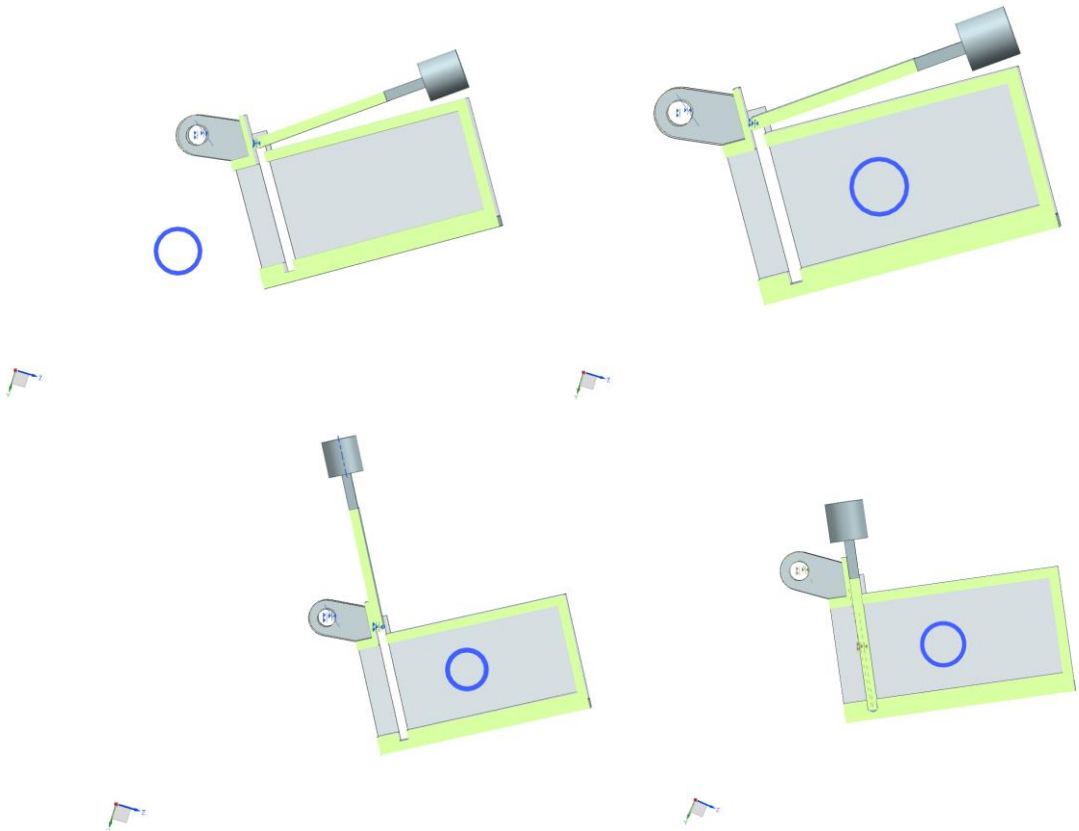

Figure 1-6: Sample Collection Pod Demonstration

The MACS Tool was designed with the intention of reducing weight and volume without sacrificing its performance, in order to meet the Micro-g NExT design requirements. Dimensioned CAD views have been added in the figure below to validate requirement compliance in Figure 1-7. Below that is a mass budget for the tool, shown in Table 1-1. These figures show the MACS tool's compliance with the 10x10x16 inch volume constraint and the 15 lbs. weight constraint.

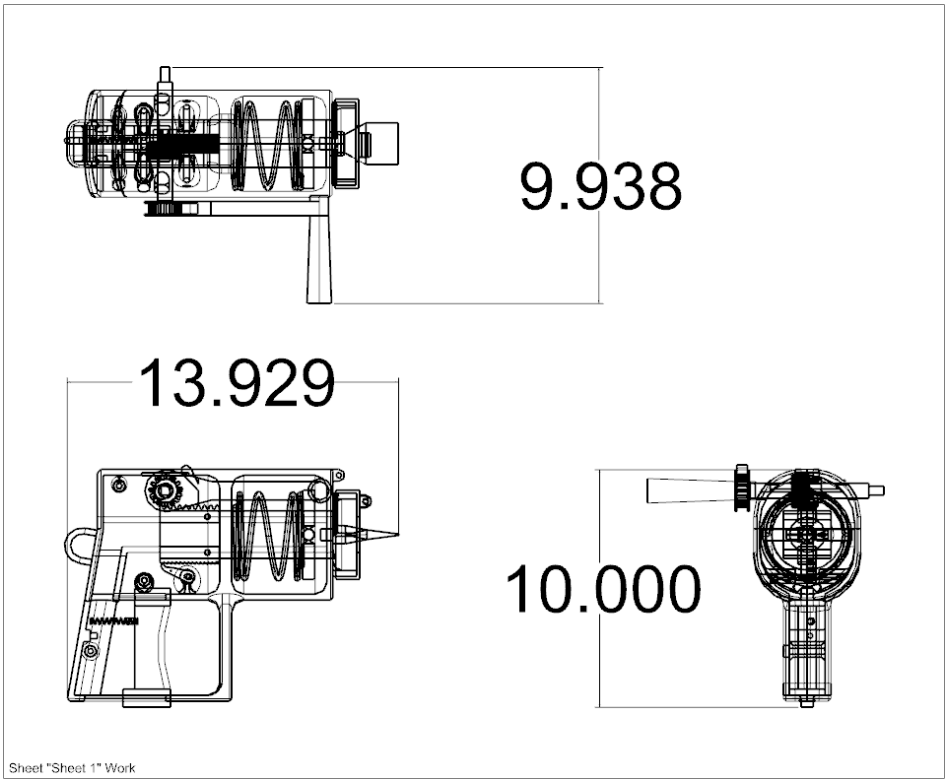

Figure 1-7: Linear Dimensions/Volume Compliance

Table 1-1: Weight Budget

Component	Material	Weight (lbs.)
Right Body	ABS	1.430
Left Body	ABS	1.540
Trigger	ABS	0.211
Vessel Attachment (x4)	ABS	0.392
Containment Vessel (x4)	Acrylic	0.736
Vessel Door (x4)	Acrylic	0.108
Aluminum Bar	Aluminum	2.578
Main Spring	Stainless Steel	0.371
Trigger Spring	Steel	0.001
Threaded Bars (x4)	Stainless Steel	0.320

Rack Gear	Steel	0.342
Ratchet Gear	Steel	0.360
Pawl	Stainless Steel	0.048
Main Gear	Steel	0.029
Ratchet Handle	Steel	0.8543
Chisel	Steel	0.235
Total		**9.56**

The MACS Tool design process began by performing an analysis to identity the top level functions necessary to chip, collect, and store a rock sample. The two top level functions identified were "chip" and "grab/collect". Initial design ideas included a common core piston with a rotating barrel of spring loaded chisel cartridges, and also a cylindrical chipper that collected the chipped samples by directing them to externally attached pods. The first idea was discarded due to the complexity of moving parts necessary to achieve the goal of collecting and storing 4 unique samples. The cylindrical chipper design was discarded due to the fact that it relied heavily on samples travelling in a favorable path where it would be collected. Both designs were utilizing spring loaded chisel heads. The designs had positive qualities that led us to consider a common base chipper with detachable sample collection pods. The design allows for sample collection at 4 sites without cross contamination while minimizing the number of moving parts.

Our top designs, that satisfy the initial function requirements of chip and collect, had been identified. The next step was to identify how the spring loaded chisel would be safely wound up and fired with as few moving parts as possible. It was decided that the most efficient way was to hand load the spring through the use of a gear/gear rack/handle that would allow the astronauts to utilize the mechanical advantage of gear ratios. A ratchet handle design was the result of a design iteration focusing on reducing the required shoulder range of motion (ROM) necessary to crank the spring back.

After the loading mechanism was validated, the next step was to develop a trigger mechanism. The main constraint in this system is the dexterity of EVA hand gloves. The MACS Tool needed to have a large enough handle to accommodate for gloved operations. A palm-press trigger handle was selected to allow for astronauts to use their palm to engage the trigger instead of an individual finger. The trigger operates on a ratchet and pawl system utilizing a linear ratchet mechanism mounted on the bottom of the chisel rod.

The trigger and spring loading system designs satisfy the chip function, but a second design had to be done to satisfy the collector function. Multiple collector pods on a rotating barrel were also ruled out due to increased system complexity. The need for sample integrity did not change, however, so the design pivoted to a single use sample collection pod that would attach to the forward operating end of the tool. After a sample is secured in a pod, the pod is designed such that it will be isolated and stored in a collection bag carried by (or secured to) the astronaut.

The pods themselves need to be secured so that samples cannot become free from containment and risk contaminating other collection sites. Therefore, a door function was identified and multiple design ideas were developed such as a "guillotine" style closing mechanism to reduce drag by minimizing surface area travelling through the water. This design, although it

satisfied the function, was not the optimal choice after the next design iteration. The pods were required to be attached and detached, requiring a locking and hinge mechanism at the base of the pods attachment point. The guillotine door operates by rotating up from the open position until it reaches a stud, then slides down a guided slot into the closed position, isolating and securing the sample.

1.5.2) Design Challenge Requirements

Table 1-2. Rock Chip Sampling Device - Design Requirements Compliance Matrix

Design Requirement Criteria	Design Compliance Method
The device shall be capable of containing chips approximately 0.5" x 0.5" x 0.5"	The device will utilize modular sample collection pods capable of holding samples 0.5" x 0.5" 0.5"
The device shall be capable of creating chips approximately 0.5" x 0.5" x 0.5"	The device will use a spring loaded chisel head capable of creating chips 0.5" x 0.5" 0.5"
The device shall create, capture, and contain at least one sample per site	The device is designed to direct chipped samples directly into sample containment pods
The device shall provide for collection of samples from four (4) separate sites without cross contamination between sites	The device is designed to accommodate for 4 separate sample containment pods
The device shall provide for storage of samples independent of one another in order to prevent cross contamination during transportation	The sample collection pods are closed off to preserve sample integrity and eliminate potential for cross contamination
The device shall prevent chipping debris from impacting the crew member	The device is designed to direct chipping debris away from the crew member
The device shall accommodate rough surfaces	The sample collection pods are mounted on a hinge to account for irregular terrain
The device shall be capable of obtaining a chip from a range of natural rock densities (specifics to be given at alter time)	The device is designed to deliver enough force on impact to create a sample regardless of rock density
The device (all parts) shall fit within a 10" x 10" x 16" volume	The device meets all volume requirements as shown in Figure 1-7.
The device (all parts) shall weigh less than 15 lbs	The device weighs approximately 9.5 lbs as shown in Table 1-1.
The device may have multiple parts that attach and detach	The device utilizes detachable sample container pods
The device may be operated manually or under power. Powered operations shall be driven pneumatically	The device is powered mechanically via loaded spring forces
The device shall allow ambidextrous operation	The device is configurable to accommodate for left or right handed users

The device shall be compatible with a chlorine water environment	The device is comprised of ABS plastic, acrylic, aluminum, stainless steel, and steel
The device shall have a tether attachment point 1" in diameter	The device has a built-in tether attachment on the rear wall of the tool

1.5.3) Tool Manufacturing

The completed MACS Tool will be comprised of both commercial off-the-shelf components as well as custom manufactured components created via additive manufacturing (3D printing) and machining. Components manufactured via 3D printing are optimized for ergonomic design and competition parameters. Purchased components were decided upon based on material, ease of implementation, and correspondence to competition parameters. Every design was carefully crafted with manufacturability and the overall task in mind.

Components such as the encasing frame and the chisel release trigger are created through additive manufacturing and rapid prototyping machinery. There are several reasons for taking this approach to the design. 3D printing offers simplicity when it comes to assembly since parts can be designed to come together in the most efficient manner possible. As mentioned earlier, the chassis of the MACS Tool is entirely 3D printed. This reduces cost of manufacturing, materials consumed and assembly time. Components such as the trigger are also 3D printed to allow for easy replacement on the off chance that a component were to be damaged in any way. A beneficial outcome of taking the additive manufacturing approach is the modularity in design that can easily be modified to fit the needs of any user, or address any unforeseen flaws in the design. The existing model can easily be modified, printed, and replaced.

The University of Illinois is equipped with several manufacturing labs available for UIUC student use. Each lab provides various rapid prototyping tools and guidance of skilled professionals ready to assist and educate. The University of Illinois Mechanical Science and Engineering Rapid Prototyping Lab will be utilized for all of the 3D printing needs.[1] The RPLab's FORTUS 400mc machine is available for student use and provides several advantages to the tool. The FORTUS 400mc's large build envelope (XYZ) of 16x14x16" and a high printer resolution of 0.127mm will allow for manufacturing the large dimensions of the MACS Tool while keeping a high level of precision.[2]

The MACS Tool is expected to withstand impact forces and surrounding pressure. For this reason, it is important to consider the materials used in the printing of 3D parts. The frame and the trigger will both be prototyped using Acrylonitrile Butadiene Styrene (ABS) on the FORTUS 400mc. ABS's strength through impact force and slight flexibility for joining components give it the necessary characteristics to create functioning final products for all of the MACS Tool's 3D printed parts.[3]

The primary source of power in this design is through the compression of the spring. When the spring expands into the equilibrium position, the force of the impact of the attached component will be enough to break off a rock sample. Because of the strength of the loading mechanism, the MACS Tool cannot use entirely 3D printed parts, so a number of off-the-shelf and slightly modified components will be used for the construction of the MACS Tool.

All components, including the handle gear, ratcheting handle and compression spring are ready upon purchase. The ratcheting handle, used to enable the astronaut's preferred method of delivering torque to the chisel, along with a stock gear, will be ordered and used as-delivered, by McMaster-Carr. The main spring powering the entire chisel mechanism will also be ordered ready to go off the shelf. Due to the heavy loads on these particular parts of the system, these components were selected from professional manufacturers.

Components such as the aluminum bar, spring brace, chisel and pawl all require minimal modifications before being introduced into the assembly. The aluminum bar will need to be modified after purchase to have slots to fit the spring and attached gears. In addition it will need to be drilled and threaded to allow for the spring brace to be attached. The spring brace will be comprised of 4 1/2 inch threaded rods cut to the desired length. The MACS Tool will use a McMaster-Carr standard issue stainless steel metal pawl modified only slightly to accommodate a string or wire hooked up to the trigger mechanism. Finally the chisel is a typical stone carving flat chisel. The steel cutting edges are tempered for use on granite and guaranteed for long-lasting use. The base of the chisel will be modified for diameter and threaded to provide easier attachment to the rest of the tool, however, the head will remain unmodified.

The remaining parts for the MACS Tool must be manufactured at various facilities offered through the University of Illinois. The linear ratchet rack gear (LRRG) is designed specifically for the MACS Tool. The LLRG works with the pawl similarly to how a pawl would work with a circular ratcheting gear, except it prevents backwards linear rather than rotational motion. The LRRG is made from steel and will be manufactured via water jet cutting available to University of Illinois Students through U of I Research Park. The abrasive water jet provides the precision necessary for the fine teeth on the LRRG at a reasonable cost. Lastly, the MACS Tool will use a custom made shaft to attach the main driving gear to the ratcheting handles. The need for this custom shaft arises out of the use of square press fit holes in the ratchet handles and a circular press fit hole in the gear. The custom LRRG and custom shaft are shown in Figures 1-8 and 1-9 below:

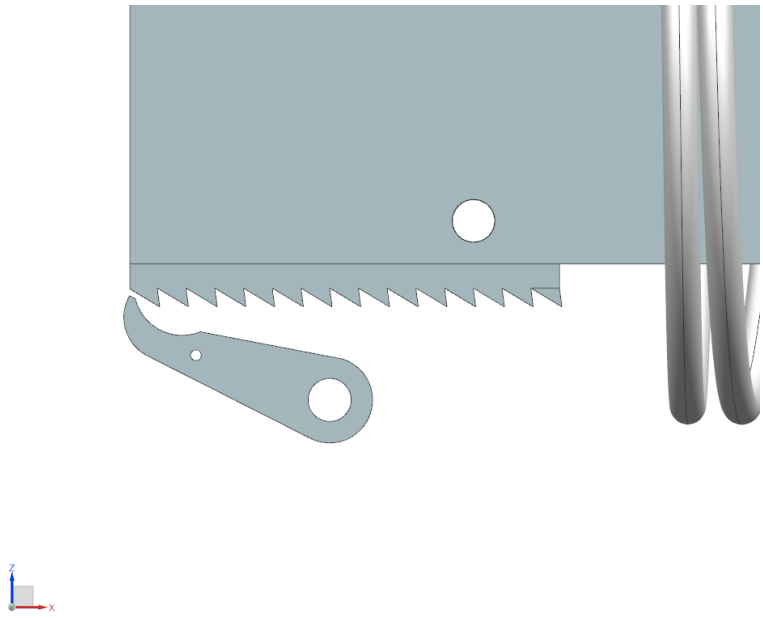

Figure 1-8: Custom Linear Ratchet Rack Gear

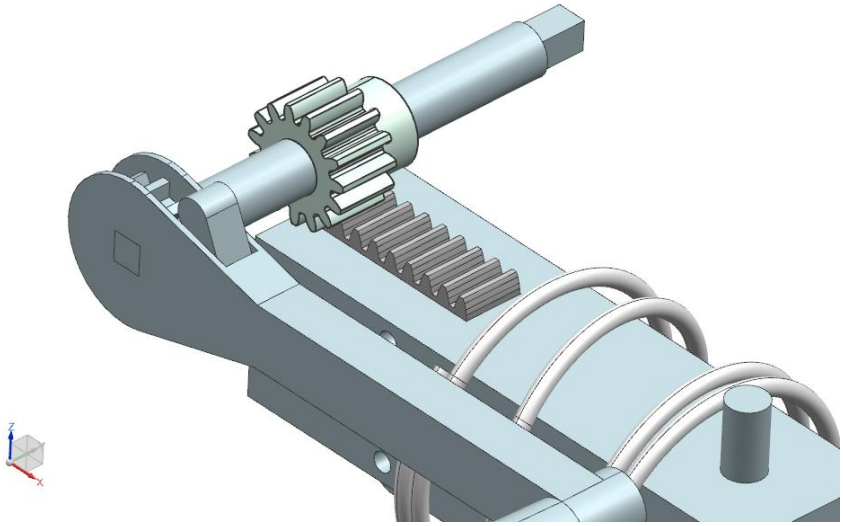

Figure 1-9: Custom Ratchet Shaft

1.6) Test Description

1.6.1) Project Motivation

The development of the Orion Multi-Purpose Crew Vehicle and Space Launch System (SLS) has allowed NASA to propose future deep space missions to asteroids. These Asteroid Redirect Missions (ARM) will begin with a robotic mission to redirect an asteroid to the Moon and placed in a Distant Retrograde Orbit (DRO). Once the asteroid is in lunar orbit, the SLS will launch a crewed Orion vehicle to the asteroid to begin sample collection and experimentation. However, EVA tool technology for sample collection in microgravity presents unique challenges, mainly storage and sample integrity. The MACS Tool accounts for these main issues by utilizing 4 sample containment pods that allow for astronauts to collect samples from 4 unique asteroid sites.

Astronauts also require unique tool designs to account for the limited mobility and dexterity while operating within the EVA suits. The MACS Tool utilizes mechanical advantages from ratchet and gear systems to minimize energy input while staying within maximum spacesuit joint torque and mobility constraints.

1.6.2) Design Validation

To validate the MACS Tool design methodology, the ISS team will perform extensive structural and performance based testing to ensure the tool operates safely and reliably. The team will perform system checkouts at the component and system level during the assembly phase of the tool. Once assembled, multiple drop tests will be performed at varying heights to ensure that the MACS Tool can withstand stress without any critical system failures. Finite element analysis will be conducted to verify design compliance with the requirement stating that the tool shall be operable at depths up to 40 feet (See Table 2-# for NBL hardware requirements). A finite element analysis (FEA) was conducted on the tool assembly to validate material and design strength requirements and the results can be seen below in Figure 1-10. These results clearly show that the tool will be able to withstand the maximum compression of the chisel spring under full load.

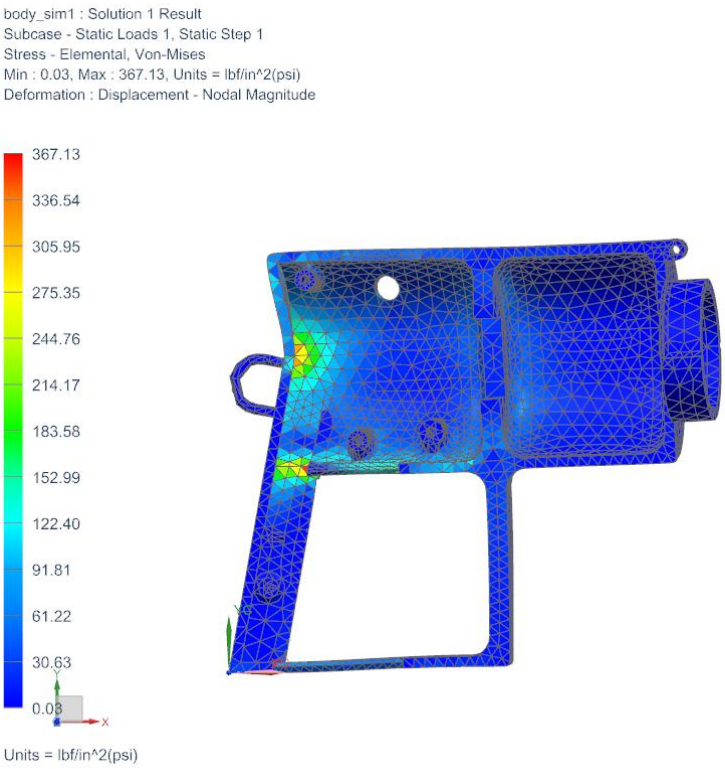

Figure 1-10: FEA Analysis

As shown by the FEA analysis results, the tool design proves to be structurally sound, and can withstand the loads it will experience while operating in the NBL. To validate performance under simulated NBL conditions, ISS will conduct underwater performance tests at a local chlorinated pool to ensure we are simulating tests within the most realistic environment possible. We will perform a full test procedure and attempt to chip a sample while underwater and wearing gloves comparable in dexterity to an EVA suit. Qualitative measurements will be taken during our mock simulation to assess the function and buoyancy of the MACS Tool. Buoyancy will be adjusted up or down as necessary using explicitly approved Neutral Buoyancy Laboratory materials.

1.6.3) Testing Procedures

Test Preparation Phase

1. Deploy the MACS Tool
2. Firmly grip the MACS Tool by the handle.
3. Safety Checkout: Ensure that the MACS trigger safety mechanism is enable
4. Safety Checkout: Ensure that the spring is unloaded by applying minimal pressure to the ratchet handle with your opposite hand
5. Using your hand, ensure that all sample collection pods are secured in the sample collection bag.

Test Execution Phase

1. Complete the Test Preparation Phase.
2. Relocate to the sample site of interest.
3. Firmly grip the MACS Tool by the trigger-handle with one hand.
4. Using your opposite hand, locate and extract the first sample collection pod from the bag and guide the attachment stud into the locking position
5. While maintaining a firm grip on the handle, locate and grip the ratchet handle with the opposite hand.
6. Begin to the crank the ratchet handle until you get physical feedback that the tool spring is fully loaded.
7. Return the ratchet handle to the neutral position (parallel to the tool body) by cranking the opposite direction.
8. Return your hand back to the trigger handle.
9. Orient the forward tip of the tool to within 0.5 to 1 inches of the sample surface.
10. Disengage the tool firing safety mechanism.
11. While maintaining a firm grip on the trigger handle, press the trigger to fire the chisel into the surface of the sample.
12. Re-engage the trigger safety.
13. Visually confirm sample collection through acrylic surface of collection pod.
14. Secure sample collection pod hatch (lift to vertical position, then slide down into slot, closing the pod).
15. Detach the sample collection pod from the forward operating position.
16. Store the sample collection pod in the sample collection bag.
17. Repeat steps 2-18 for the remaining (3) sample collection pods.
18. Prepare for Test Closeout Phase

Test Closeout Phase

1. Complete the Test Execution Phase.
2. Ensure that the trigger safety mechanism is engaged.
3. Ensure that the MACS Tool firing spring is unloaded.
4. Ensure that all sample collection pods are safely stowed in the sample collection bag.
5. Deliver sample collection pods to desired location
6. Store the MACS Tool after successful sample delivery

1.6.4) Anticipated Test Results

The Neutral Buoyancy Lab provides the ideal environmental conditions to simulate extra-vehicular activities and assess astronaut and equipment performance for current and future NASA missions. The ISS Micro-g NExT team anticipates that the live tests will provide valuable design feedback on the functionality of handheld/hand cranked mechanical-spring systems for collecting asteroid rock samples in the microgravity environment. Meeting the tool design and experiment requirements is top priority. However, the team is also interested in feedback on the human factors

and qualitative assessments from the NBL divers. Though this feedback will be subjective, a tool that looks and feels natural in the astronauts' hands will lead to greater EVA performance.

2) Experiment Safety Evaluation

2.1) NBL Mockup and Training Hardware Requirements Compliance

The MACS Tool was designed within the full context of the Neutral Buoyancy Laboratory Mockup and Training Hardware Requirements set forth by the NASA Microgravity University program office. To illustrate the design team's efforts to satisfy NBL requirements, a set of requirement compliance matrices.

Table 2-1. Neutral Buoyancy Lab Compliance Matrix - Tools

Design Requirement Criteria	Compliance Method
All tools must have a tether loop which will allow the astronaut to use a tether with hooks to restrain the tool.	The tool has a built in tether on the rear facing surface of the handle, but does not interfere with tool operation.
All tools must be operable with EVA gloved hands.	The tool handle is designed to be large enough to allow for the size of the EVA glove.
Tools must not have holes or openings which would allow/cause entrapment of fingers.	The tool has no holes on the main body that would cause entrapment and the trigger mechanism does not move beyond a safe operating range.
Hydraulic Power Requirements.	The tool design does not utilize hydraulics.
Pneumatic Power Requirements.	The tool design does not utilize pneumatics.
Electrical Power Requirements.	The tool design does not utilize electronics.

Table 2-2. Neutral Buoyancy Lab Compliance Matrix - Tools and Test Beds

Design Requirement Criteria	Compliance Method
The tool shall survive total submersion in water that contains 0.5 to 3.5 parts per million of free chlorine.	The tool is designed using 3D printed ABS plastic and NBL approved metals that are not affected by chlorine rich environments.
The tool shall survive an ambient temperature range from +82 degrees F to +88 degrees F.	The tool is designed using 3D printed ABS plastic and NBL approved metals which are only at risk at temperatures much higher than the ambient temperature range.
The tool shall be capable of operating at a fully submersed depth of 40 feet.	The tool is designed using 3D printed ABS plastic and NBL approved metals that will not be negatively affected by the pressure at 40 feet as shown in the FEA analysis.
The tool will be constructed using only NBL approved materials.	The tool design is comprised of ABS plastic, aluminum, and stainless steel.

The tool will be constructed using only NBL approved lubricants.	The tool is designed using only NBL approved materials.
Any extra material (e.g. gels) must be approved by the NBL authorities prior to implementation.	The tool is designed using only NBL approved materials.
The tool shall not contain any sharp edges or items capable of cutting or puncturing items coming into contact with them.	The tool is designed to have no sharp edges capable of putting the EVA suit at risk.
The tool shall be designed such that it does not have the potential to harm the handler or others in the area.	The tool design integrates safety mechanisms and procedures to eliminate the potential risk of harming those in its vicinity.
The tool shall be designed to specify manufacturing to remove burrs, break all sharp edges and round all corners.	The tool materials will be manufactured such that burrs and sharp edges will be removed and all corners will be rounded.
The tool shall be designed with drain holes or geometry to allow the free flow of air and water as required to support submersion and removal to and from the NBL pool.	The tool design incorporates geometry and drain holes to encourage the free flow of air and water through the system.
The tool shall contain the following labels: mate/de-mate alignment marks, operation indicators as required.	The tool will incorporate mate/de-mate alignment marks, operation indicators, and all labels necessary to safely operate the tool.
The tool shall contain the following labels: caution and warning tags for hazard areas, hardware identification, and any additional safety labels required by the Test Readiness Review.	The tool will be manufactured to incorporate hazardous area markings, alignment marks, and additional labels will be added at the request of NBL staff as needed.
The tool must withstand normal handling or kickloads and not present a safety hazard.	The tool design incorporates added structural rigidity to accommodate for kickloads and handling.

2.2) Material Selection

For purposes of producing reliable data when testing in the Neutral Buoyancy Laboratory, all materials in the design area approved for application use in chlorinated water. Further precautions will be taken in manufacturing to avoid contamination of the tool as well.

A major portion of the tool will be constructed using rapid prototyping plastics, specifically Acrylonitrile Butadiene Styrene (ABS), a material permitted according to the NBL hardware requirements documents provided. The Material Safety Data Sheets (MSDS) for each material used in the tool have been obtained and included in the proposal. Included in Appendix C are the MSDS for all materials being used in the design: ABS, Aluminum 6061-T6511, steel, 18-8 stainless steel, Acrylic Plexiglas, and music wire,. All of the previously mentioned sheets will be used as a reference by the team during construction to ensure safety in all operations.

2.3) EVA Safety

Astronaut safety during an EVA is of utmost importance to the design team. For this design to be considered a success the safety of astronauts must be a top priority during the design process. To ensure that this tool is completely safe and reliable the NASA "General EVA Safety Design Requirements" were used as a guideline in the design process. This was done to ensure the tool could be easily adapted to space environments and completely functioning and operable given proper testing and manufacturing. The compliance of the design with the requirements are shown in Table 2-3:

Table 2-3: EVA Safety Compliance Matrix

Safety Requirement	Compliance
Temperature	The tool is designed without any heat producing sources/mechanisms.
Radiation	The tool is designed without any radiation sources nor does it protect the astronaut from radiation.
Micrometeoroids and Debris	The tool is designed to direct the chipped rocks away from the astronaut into the forward sample collector, eliminating the risk of debris deflecting back into the astronaut.
Chemical Contamination	The tool is designed without the use of any hazardous chemicals.
Edges and Protrusions	This tool is designed without any sharp edges or protrusions to prevent any tears or punctures to the astronauts EVA equipment.
Hazardous Equipment	The tool is designed within parameters that eliminated the use of potentially hazardous equipment that could cause a tear or puncture to the astronauts EVA equipment.
Ingress/Egress	The tool is designed within the size constraints provided, making it easily accessible through any ingress/egress hatch.
Power Sources	This tool contains no power sources.
Transmitters	This tool contains no transmitters.
Tethers	This tool has a tether on the rear facing side of the handle.
Ignition Sources	This tool contains no ignition sources.
Positive Pressure	Not applicable to this device.
Electrical Voltage	This tool contains no electrical sources.

2.4) Test Week Tool Requirements

The team is taking several measures in the event that a part of the tool is broken or damaged at the testing facility. To prepare for the worst case scenario the team will bring a fully equipped toolkit and spare parts required to fix any problems that may arise. The toolkit will consist of all the equipment used in the assembly process and components such as shafts, springs and chisels will also be kept on hand. All members attending will have learned the full assembly process. Therefore any member will be capable of taking care of repairs on the spot at the testing facility.

2.5) Test Equipment Data Package (TEDP) Compliance

A final document will be submitted by the Illinois Space Society Micro-g NExT team at least six weeks prior to testing in the Neutral Buoyancy Laboratory. This document will provide a comprehensive safety overview of the finalized design in greater detail.

3) Outreach Plan

3.1) Objectives

The Illinois Micro-g NExT Team is a subsidiary to the Illinois Space Society (ISS), a chapter of the Students for the Exploration and Development of Space (SEDS). The Illinois Micro-g NExT team is committed to furthering ISS's goals of educating and inspiring future generation of STEM enthusiasts.

The objective of ISS outreach events, therefore, is to stimulate the young minds and enhance their understanding of space exploration. The Micro-g Team will focus on the significance of exploration and the study of asteroids in our solar system. The team will focus on introducing current space exploration problems such as mining and probing asteroids. With the numerous outreach events planned, the team hopes to inspire the younger generations about getting involved in space exploration.

3.2) Social Media

The use of social media is one of the fundamental platforms that the Illinois Space Society employs to organize events, publish significant milestones and share space related news. Facebook and Twitter accounts are the main form of mass communication with the University of Illinois and the general public. On these pages, which focus on reaching larger audiences, the public is updated on the latest developments in the Micro-G NExT team as well as the educational outreach events being hosted.

A website also exists for those who wish to learn about the developments of the Micro-G NExT team in greater detail. It contains a brief biography of each team member and their interests in space exploration. The website also elaborates on the current status of each subsection of the team in depth as each member progresses through the design and testing phases. To finish off, the website also entails the history of the team's efforts in previous challenges explaining design details and the outcome of the tool. The Micro-g NExT specific website can be visited at www.illinoismicrog.weebly.com. The Illinois Space Society website can be visited at http://iss.ae.illinois.edu. With all of these outlets, the team hopes to continue reaching newer audiences and spreading awareness of the developments in space exploration.

3.3) Audiences

While ISS reaches out to students in grades K-12, and has presentations and demonstrations targeted to each age group, the majority of students that ISS interacts with are grades 1-5. This is the age at which an introduction to the STEM fields has the most potential to affect the student.

The target audience throughout this endeavor will be students in grades K-12. The outreach plans, however, vary with the age and maturity levels of the audience. Students in the fifth grade or higher have courses focusing heavily in math and sciences and therefore can develop a deeper understanding of the material presented to them during outreach events. This is a crucial point in their education where they are developing interests and maturing their analytical skills, and it is vital to open their minds to STEM.

In its experience organizing and holding educational outreach events, ISS has found that many schools lack the time or funding to properly introduces kids to the STEM fields. Because of this, ISS often funds these events and works around the schedules of interested teachers and students. Among several smaller outreach activities, ISS will be involved in four main outreach events throughout the 2015-2016 academic year. These events are listed in Table 3-1 below.

Table 3-1: Planned Academic Year Outreach

Date	Outreach Event
November 7th	Engineering Council StemX Event
Early November	Lincoln Trail BLAST After School Enrichment Program
March 11th-12th	University of Illinois Engineering Open House
April 11th, 25th	Illinois Novaree [4]

Engineering Council StemX Event

StemX is dedicated to helping students enhance their interest in STEM. To better portray vast potential of STEM, the Illinois Space Society has put together a few demonstrations and presentations which would be of interest to high school students. Some of the topics that are going to be covered include an introduction to rockets, astronomy and space science with a demonstration of a hybrid rocket engine and Space Shuttle tile.

Lincoln Trail BLAST - After School Enrichment Program

The Illinois Space Society is also participating in an after school enrichment program geared towards students from various districts around central Illinois, currently limited to Lincoln Trail Elementary School. Through BLAST, students will be able to engage in interactive presentations about astronomy, rocketry, space exploration history as well as the current aspirations of the space industry, including Liquid Nitrogen and Space Shuttle tile demonstrations.

University of Illinois Engineering Open House

The University of Illinois's College of Engineering hosts their annual open house every March during which almost 20,000 people (including families and students) come to learn about the latest projects being developed in the College of Engineering. The Illinois Space Society Micro-g NExT team will be demonstrating the function of the MACS Tool along with a poster about the design and manufacture of the tool. The demonstrations will be accompanied by further explanations about the complex missions of astronauts and the difficulties of manned space flight.

Illinois Novaree

In this two weekend STEM camp, the Illinois Space Society will be working with local Boy Scouts and Girl Scouts to achieve their Space Exploration badge. This will be accomplished by incorporating elements of the MicroG NExT challenge and discussing NASA's plans for asteroid bound missions alongside the standard scout Space Exploration badge curricula.

3.4) Activities

ISS has created a set of engaging and fun educational outreach demonstrations to engage and capture the imagination of onlookers in addition to the presentation of the project itself. These core demonstrations are used in for all age groups, though their presentation varies according to the general age of the audience. Some demonstrations involve open flames, but the utmost care is taken to ensure the safety of all onlookers at all times.

Liquid Nitrogen is a cool and fun way of demonstrating the effect of temperatures on materials, and provides a jumping point for teaching kids how the manipulation of temperature is used in the space industry. A small dewar is used to free various objects and demonstrate their altered properties. For example: pennies are super-cooled, and then smashed to show how brittle metals become when cold. A similar effect is demonstrated with frozen flowers. At the end of the demonstration, the students are always given a flash-frozen marshmallow as a treat.

On the opposite end of the temperature spectrum, ISS has access to a section of tile from the Space Shuttle thermal protection system. We use this along with a blow torch and laser thermometer to show the temperatures the tile can withstand on one end without heat transferring to the other. Along with the Liquid Nitrogen demonstration, the shuttle tile demonstration is great for starting discussion about the temperature extremes encountered in space flight an the effects they have on the materials used in space.

ISS has also built a small hybrid rocket motor for demonstration purposes. The motor uses gaseous oxygen as the oxidizer and a clear acrylic cylinder as the fuel. The clear acrylic cylinder is compressed between and aluminum inlet for the oxygen on one end and a nozzle at the other. It is both the fuel grain and the combustion chamber, so onlookers can see the flame front as it burns inside the engine. This motor is safe and promotes interest in spacecraft propulsion systems as well as serves as a jumping off point for an introduction into the basic principles behind rocket based propulsion systems.

3.5) Media Plan

Media outreach for the MACS Tool team will be conducted via both electronic and physical news media.

Electronic communication will happen through a variety of means. First, the Flyer: a department of aerospace engineering news letter detailing aerospace related events happening in the University of Illinois at Urbana-Champaign. Second, the Illinois Space Society publishes a weekly newsletter that features technical project events and milestones. The MACS Tool team also has a website which will be regularly updated with the team's progress and used as a reference for other news outlets. Lastly, the MACS team will provide updates to social media through the ISS Facebook and Twitter pages.

Physical advertising will consist of strategically placing the ISS team flyers in high traffic areas to maximize exposure. The team will also contact local and student run newspapers, such as the News Gazette and Daily Illini, to publish news stories documenting the ISS Micro-g NExT experience from design through construction to testing.

4) Administrative Requirements

4.1) Institution's Letter of Endorsement

An institutional letter of endorsement from the University of Illinois' Department of Aerospace Engineering is attached below.

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Department of Aerospace Engineering
College of Engineering
306 Talbot Laboratory, MC-236
104 South Wright Street
Urbana, IL 61801-2935 USA

October 26, 2015

To Whom It May Concern:

The Aerospace Engineering Department at the University of Illinois is aware and supporting the Illinois Space Society Student Team for the Microgravity Neutral Buoyancy Experiment Design Proposal. The team project proposal is the "Modular Asteroid Chip Sampler Tool." The team is comprised of the following students:

Zach Fester	Emilio Garcia
Paul De Trempe	Sarosh Hussain
	David Salmi

The team is being advised by Assistant Professor Grace Gao of the Aerospace Engineering Department. We endorse and approve their involvement in the NASA Microgravity University Program.

Sincerely,

Philippe Geubelle
Department Head
Aerospace Engineering

telephone 217-333-2651 • fax 217-244-0720 • url http://www.ae.illinois.edu

4.2) Statement of Supervising Faculty

A letter of indorsement from the supervising faculty, Assistant Professor Grace Gao, is attached below.

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Department of Aerospace Engineering
College of Engineering
306 Talbot Laboratory, MC-236
104 South Wright Street
Urbana, IL 61801-2935 USA

Oct. 26, 2015

As the faculty advisor for an experiment entitled "Modular Asteroid Chip Sampler Tool" proposed by a team of undergraduate students from the University of Illinois at Urbana-Champaign, I concur with the concepts and methods by which this experiment will be conducted. I will ensure that all reports and deadlines are completed by the student team members in a timely manner. I understand that any default by this team concerning any Program requirements (including submission of final report materials) could adversely affect selection opportunities of future teams from the University of Illinois at Urbana-Champaign.

Participating Students:

Zach Fester
Paul DeTrempe
Emilio Garcia
Sarosh Hussain
David Salmi

Best regards,

Grace Xingxin Gao
Assistant Professor
Dept. of Aerospace Engineering
Coordinated Science Laboratory
University of Illinois
at Urbana-Champaign

E-mail : gracegao@illinois.edu
Phone : (217) 333 6360
http://gracegao.ae.illinois.edu

4.3) Statement of Rights of Use

As a team member for a proposal entitled "The MACS Tool" proposed by a team of undergraduate students from the University of Illinois at Urbana-Champaign, I will and hereby do grant the U.S. Government a royalty-free, nonexclusive and irrevocable license to use, reproduce, distribute (including distribution by transmission) to the public, perform publicly, prepare derivative works, and display publicly, any data contained in this proposal in whole or in part and in any manner for Federal purposes and to have or permit others to do so for Federal purposes only.

As a team member for a proposal entitled "The MACS Tool" proposed by a team of undergraduate students from University of Illinois at Urbana-Champaign, I will and hereby do grant the U.S. Government a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States any invention described or made part of this proposal throughout the world."

Zachary Foster

Paul Rybarczyk

Sarosh Hussain

Emilio Garcia

David Salmi

4.4) Budget Statement

The MACS Tool will consist of commercial off the shelf (COTS) materials from various vendors, 3D printed plastics, and custom machined components. COTS hardware budgeting was based on advertised prices by the respective suppliers. Additively manufactured components were priced based on a mass and volume metrics. For custom machined hardware, quoted rates were applied to the estimated machine time to complete the required parts. A summary of these costs is listed below in Table 4-1:

Table 4-1: Manufacturing and Build Cost

Component	Quantity	Cost [USD]
6061-T6511 Aluminum Square Bar	1	$25.24
18-8 Stainless Steel Threaded Rod	1	$9.31
Husky 3-Piece Chisel Set	1	$17.98
Linear Compression Spring	1	$23.44
Linear Ratchet	1	Machined
Gear-Handle Mating Shaft	1	Machined
McMaster-Carr Ratcheting Handle	1	$57.11
McMaster-Carr Steel Gear	1	$27.03
McMaster-Carr Steel Gear Rack	1	$86.15
McMaster-Carr Steel Pawl	1	$45.22
Trigger Compression Spring	1	$5.26
M6 12 mm. Phillips Screws (2-Pack)	3	$2.64
1.75 mm ABS Filament (White) (1kg Roll)	2	$47.98
1.7 mm Braided Kevlar Cord - 400lb Tested (30 ft Reel)	1	$10.99
Acrylic Sheets (11x14 in. Sheets)	2	$9.56
Machining and Materials Cost		$75.00
Shipping + Taxes (15%)		$50.00
Total Development Cost:		**$492.91**

Cost estimates for the educational outreach events listed in the Section 3 are listed below in Table 4-2:

Table 4-2: Total Educational Outreach Cost

Educational Outreach Component	Cost [USD]
Event Travel	$175.00
Presentation / Activity Materials	$225.00
Miscellaneous Supplies	$75.00
Total Educational Outreach Cost	**$475.00**

The travel budget was developed on the assumption that all 5 team members will be travelling to Houston. A cost margin has been implemented to allow for the faculty advisor to attend the test week should schedule allow. The summarized cost estimates are listed below in Table 4-3:

Table 4-3: Total Travel Cost

Test Week Travel Component	Cost [USD]
Faculty Advisor Flight (Round Trip)	$300.00
Rental Car	$300.00
Gas	$300.00
Hotel (2 Rooms for 4 Nights)	$1,000.00
Total Travel Cost	**$1,900.00**

The overall project budget is listed below and contains all tool manufacturing/construction, educational outreach, and test week travel elements for the ISS Micro-g NExT Team.

Table 4-4: Total Project Cost

Total Micro-g NExT Project Cost	Cost [USD]
Tool Manufacturing and Construction	$492.91
Test Week Travel	$1,900.00
Educational Outreach	$475.00
Total Overall Cost	**$2,867.91**

4.5) Funding Statement

Funding for all project components comes from a variety from university and outside sources. As a subsidiary of the Illinois Space Society, the ISS Micro-g NExT team receives partial funding for from the ISS technical project budget. Also, the College of Engineering, through Engineering Council, provides funding to technical projects that have the potential to benefit the college and represent the proudly represents the values the College of Engineering. The Micro-g NExT team will also seek funding from ISS corporate sponsors, as well as material/hardware donations to reduce overall manufacturing costs.

Funds for travel and lodging required for test week in Houston will be obtained from a variety of sources. The Student Organization Resource Fee (SORF) group partially funds travel and lodging for student group trips. The Engineering Design Council and ISS corporate sponsors, along with tool manufacturing funding, will provide partial funding for travel and lodging. The amount of funding from the combined sources will provide the necessary amount to complete all tasks with a cost margin to allow for project cost growth, although that is not anticipated.

The Micro-g NExT team, through Illinois Space Society, other university resources, and corporate contacts will receive adequate funding with an anticipated budget margin of over 16%. In the highly unlikely event that the team requires further funding, the Illinois Space Society will acquire the necessary funds to finish the project.

Table 4-5: Funding Projections

Funding Projections	Amount [USD]
ISS Technical Project Budget	$600.00
S.O.R.F	$1,330.00
Corporate Sponsors	$850.00
Engineering Council	$650.00
Total Funding Projection	**$3,430.00**

The Micro-g NExT team, through Illinois Space Society, other university resources, and corporate contacts will receive adequate funding with an anticipated budget margin of over 16%. In the unlikely event that the team requires further funding, the Illinois Space Society will acquire the necessary funds to finish the project.

4.6) Parental Consent Forms

All members of the University of Illinois Micro-g NExT team are at least 18 years of age, therefore, no parental consent forms are required.

Appendix A: References

[1] "Our Printers" University of Illinois Department of Mechanical Science and Engineering Rapid Prototyping Lab. n.p, n.d. Web. 25 October 2015. <http://rpl.mechse.illinois.edu/printers.html#fdm>.

[2] "FORTUS 400mc" University of Illinois Department of Mechanical Science and Engineering Rapid Prototyping Lab. Stratasys. n.p. 16 July 2015. Web. 25 October 2015. <http://rpl.mechse.illinois.edu/img/printers/fdm.pdf>.

[3] "FORTUS ABS-M30 Characterization of Material Properties" Stratasys. USGlobalImages. 05 October 2015. Web. 25 October 2015. <http://usglobalimages.stratasys.com/Main/Files/Material%20Property%20Studies/MSS_FDM_ABSM30PropertiesReport.pdf?v=635784480067977405>.

[4] "Space Exploration" Boy Scouts of America,n.p. n.d.Web. 25 October 2015. <http://www.scouting.org/scoutsource/BoyScouts/AdvancementandAwards/MeritBadges/mb-SPEX.aspx>.

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[6] "Illinois Learning Standards" Illinois State Board of Education. n.p, n.d. Web. 25 October 2015.<http://www.isbe.state.il.us/ils/science/standards.htm>.

[7] "5Es Overview: 'The 5E Instructional Model'" NASA Education. NASA, n.d. Web. 25 October 2015.<http://www.nasa.gov/audience/foreducators/nasaeclips/5eteachingmodels/>.

[8] BuyMetal, "Aluminum Square Bar 6061-T6511 2"(A)" [Online]. Available: http://store.buymetal.com/aluminum-square-bar-6061-t6511-2.html?gclid=Cj0KEQjw44exBRCu8vfS_bPEtNoBEiQACrt001fFRwjhNqcxoS4Og3j6W1FvW4lS5GOyHQ0OV8tUlPkaAps78P8HAQ.

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[10] The Home Depot, "Husky 3-Piece Pro Chisel Set" [Online]. Available: http://www.homedepot.com/p/Husky-3-Piece-Pro-Chisel-Set-HDA10300AV/100013956

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[12] McMaster-Carr, "Steel Ratchet Crank Handle 3/8" Square Through Hole, 7" Handle" [Online]. Available: http://www.mcmaster.com/#6393k11/=zkgrw4

[13] McMaster-Carr, "Metal Gear—14-1/2 Degree Pressure Angle Press-Fit Mount, 12 Pitch, 15 Teeth" [Online]. Available: http://www.mcmaster.com/#6325k79/=zkgsc7

[14] McMaster-Carr,"Metal GearRack—14-1/2 Degree Pressure Angle with Mounting Holes, 12 Pitch" [Online]. Available: http://www.mcmaster.com/#5170t4/=zkgsov

[15] McMaster-Carr, "Pawl for Ratcheting Gear" [Online]. Available: http://www.mcmaster.com/#6283k32/=zkgt8p

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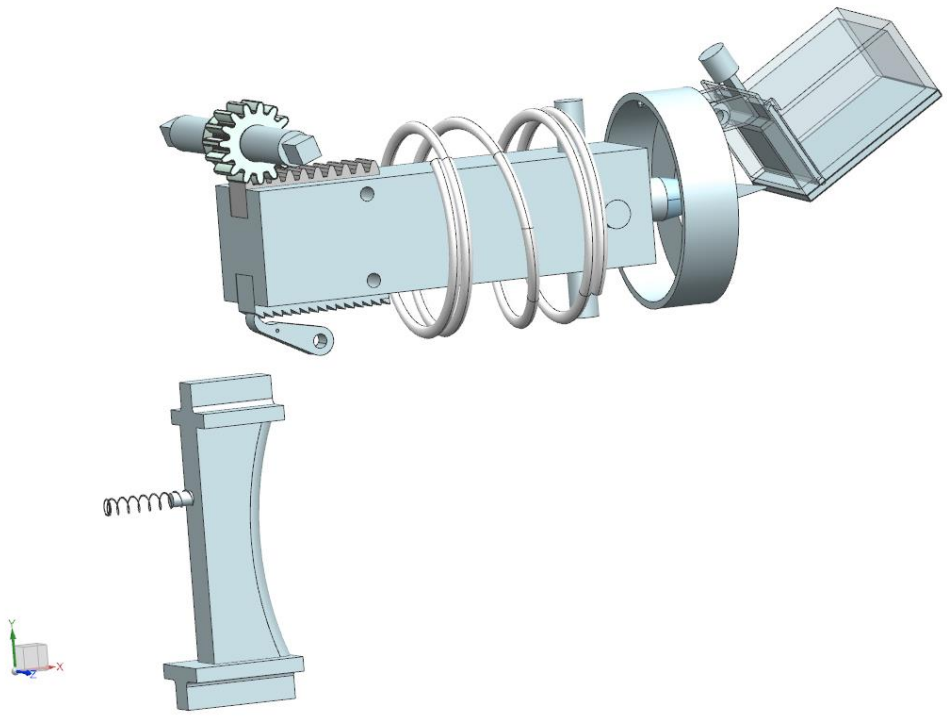
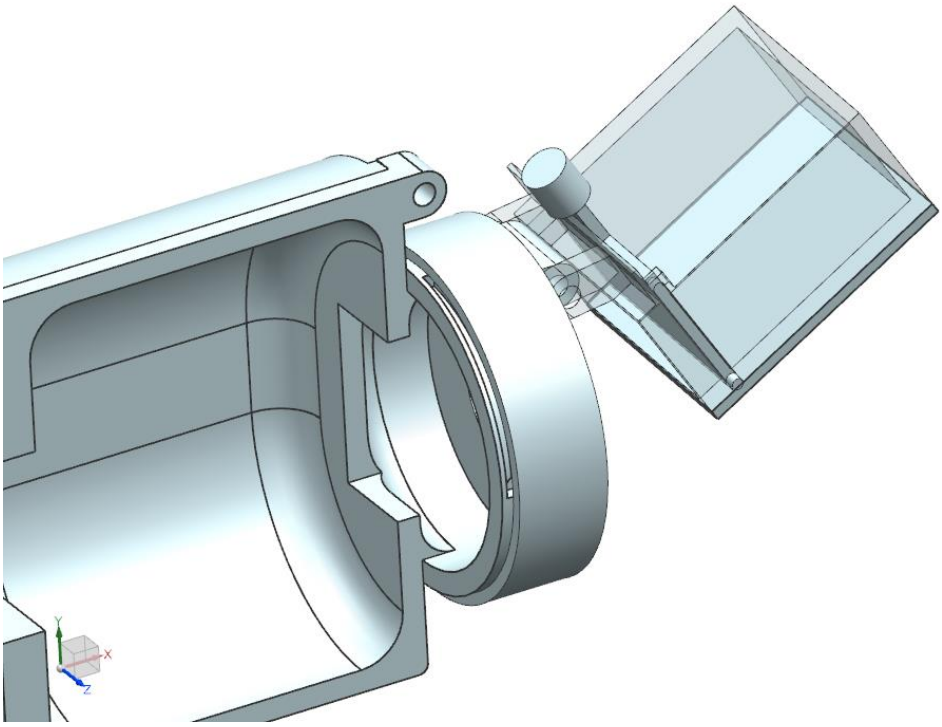
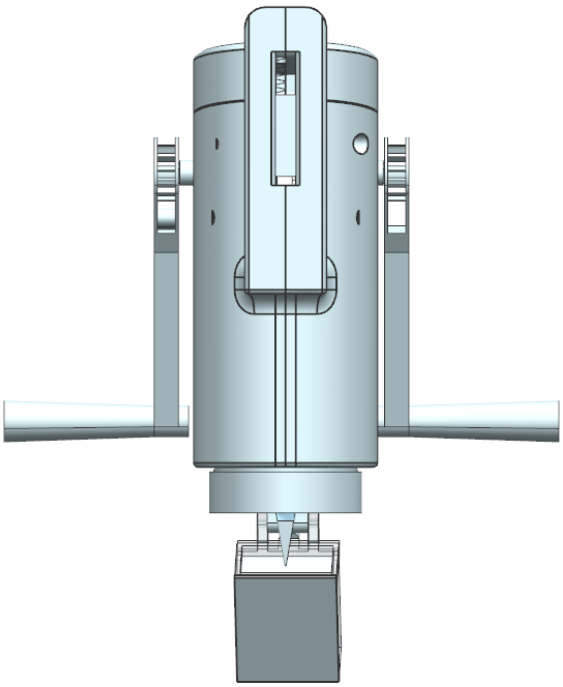
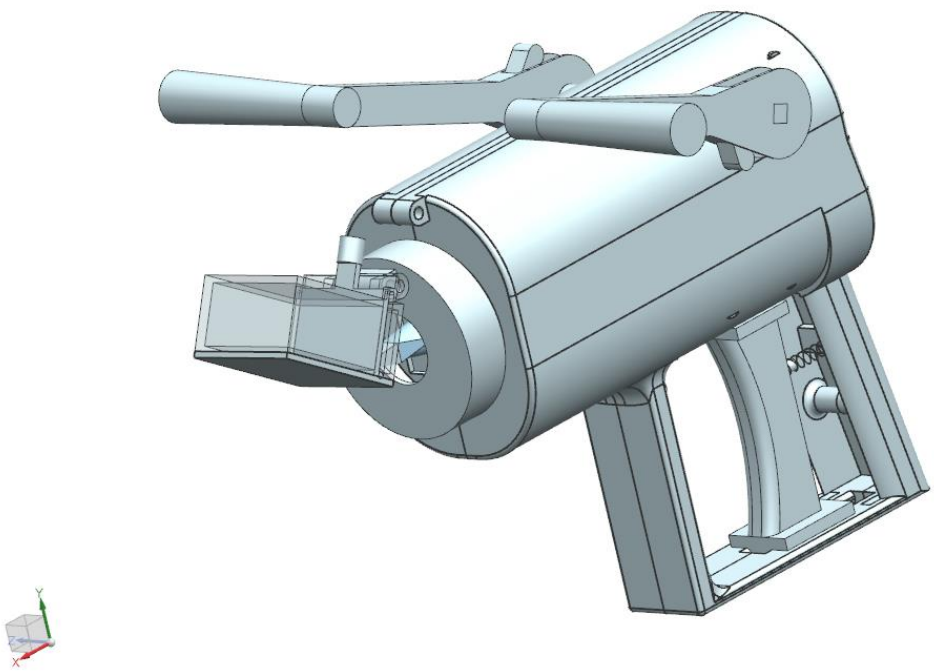
Appendix B: Additional CAD Model Views









Appendix C: Material Safety and Data Sheets

MATERIAL SAFETY DATA SHEET

1. Product and Company Identification

Material name	**6xxx SERIES ALLOYS WITH ALCOA 951 PRETREATMENT**
MSDS Number	1008
Version #	06
Revision date	October 5, 2012.
CAS Number	Mixture
Product use	Various fabricated aluminum parts and products
Synonym(s)	WROUGHT ALUMINUM PRODUCTS, 6xxx SERIES ALLOYS WITH ALCOA 951 PRETREATMENT AND DRY FILM LUBRICANT; INCLUDES ONLY ALLOYS: 6111-T4, 6111-T43, 6022-T4, 6022-T4E32, 6022-T4E15, 6022-T40, 6061-T6
Manufacturer	Alcoa Inc. 201 Isabella Street Pittsburgh, PA 15212-5858 USA Health and Safety Tel: 1-412-553-4649 Health and Safety Fax: 1-412-553-4822 Health and Safety Email: accmsds@alcoa.com
Emergency Information	USA: Chemtrec: +1-703-527-3887 +1-800-424-9300 (24 Hour Emergency Telephone, multiple languages spoken); ALCOA: +1-412-553-4001 (24 Hour Emergency Telephone, only English spoken)
Website	For a current Material Safety Data Sheet, refer to Alcoa websites: www.alcoa.com or internally at my.alcoa.com EHS Community

2. Hazards Identification

Emergency overview

Solid. Silver colored. Odorless. Non-combustible as supplied. Small chips, fine turnings and dust from processing may be readily ignitable.

Explosion/fire hazards may be present when (See Sections 5, 7 and 10 for additional information):
- Dust or fines are dispersed in air.
- Chips, dust or fines are in contact with water.
- Dust and fines are in contact with certain metal oxides (e.g., rust, copper oxide).
- Molten metal in contact with water/moisture or certain metal oxides (e.g., rust, copper oxide).

Dust and fumes from processing: Can cause irritation of the eyes, skin and respiratory tract.

Potential health effects

The following statements summarize the health effects generally expected in cases of overexposures. User specific situations should be assessed by a qualified individual. Additional health information can be found in Section 11.
The health effects listed below are not likely to occur unless processing of this product generates dusts or through direct contact

Eyes	Dust or fume from processing: Can cause irritation to the eyes.
Skin	Dust or fume from processing: Can cause skin irritation. Prolonged or repeated skin contact may cause dermatitis.

Inhalation

Health effects from mechanical processing (e.g., cutting, grinding):
Dust: Can cause irritation of the upper respiratory tract. Chronic overexposures: Can cause reduction in the number of red blood cells (anemia), skin abnormalities (pigmentation changes), scarring of the lungs (pulmonary fibrosis), central nervous system damage, secondary Parkinson's disease and reproductive harm in males.

Additional health effects from elevated temperature processing (e.g., welding, melting):
Dust and fumes from processing: Can cause irritation of the respiratory tract. Acute overexposures: Can cause metal fume fever (nausea, fever, chills, shortness of breath and malaise), reduced ability of the blood to carry oxygen (methemaglobin) and the accumulation of fluid in the lungs (pulmonary edema). Chronic overexposures: Can cause respiratory sensitization, and lung cancer.

Carcinogenicity and Reproductive Hazard

Product as shipped: Does not present any cancer or reproductive hazards.

Dust from mechanical processing: Does not present any cancer hazards. Can present a reproductive hazard for males (Manganese).

Dust and fumes from welding or elevated temperature processing: Can present a cancer hazard (Hexavalent chromium compounds, Welding fumes). Can present a reproductive hazard for males (Manganese compounds).

Medical conditions aggravated by exposure to product

Dust and fumes from processing: Asthma, chronic lung disease, Secondary Parkinson's disease and skin rashes.

3. Composition / Information on Ingredients

Composition comments

Complete composition is provided below and may include some components classified as non-hazardous.

Components	CAS #	Percent
Metal	-	-
Aluminum	7429-90-5	>90
Magnesium	7439-95-4	<3.1
Silicon	7440-21-3	<1.9
Manganese	7439-96-5	<1.5
Copper	7440-50-8	<1.4
Iron	7439-89-6	<1.2
Zinc	7440-66-6	<1.1
Chromium	7440-47-3	<0.5
Dry Lubricant†	CASNo. Not available	<1.0

Additional Information

† Proprietary ingredient, mixture: Aliphatic hydrocarbons, fatty acids and surfactants.
Additional compounds which may be formed during processing are listed in Section 8.

4. First Aid Measures

First aid procedures

Eye contact

Dust and fumes from processing: Rinse eyes with plenty of water or saline for at least 15 minutes. Consult a physician.

Skin contact

Dust and fumes from processing: Wash with soap and water for at least 15 minutes. Get medical attention if irritation develops and persists.

Inhalation

Dust and fumes from processing: Remove to fresh air. Check for clear airway, breathing, and presence of pulse. If breathing is difficult, provide oxygen. Loosen any tight clothing on neck or chest. Provide cardiopulmonary resuscitation for persons without pulse or respirations. Consult a physician.

Most important symptoms and effects, both acute and delayed	Health effects from mechanical processing (e.g., cutting, grinding): Dust: Can cause irritation of the upper respiratory tract. Chronic overexposures: Can cause reduction in the number of red blood cells (anemia), skin abnormalities (pigmentation changes), scarring of the lungs (pulmonary fibrosis) secondary Parkinson's disease and reproductive harm in males. Additional health effects from elevated temperature processing (e.g., welding, melting): Dust and fumes from processing: Can cause irritation of the respiratory tract. Acute overexposures: Can cause metal fume fever (nausea, fever, chills, shortness of breath and malaise), the accumulation of fluid in the lungs (pulmonary edema), central nervous system damage and reduced ability of the blood to carry oxygen (methemaglobin). Chronic overexposures: Can cause respiratory sensitization, scarring of the lungs (pulmonary fibrosis) and lung cancer.
Notes to physician	In case of shortness of breath, give oxygen. Keep victim warm. Symptoms may be delayed.
General advice	If exposed or concerned: Get medical advice/attention. Show this safety data sheet to the doctor in attendance.

5. Fire Fighting Measures

General fire hazards	This product does not present fire or explosion hazards as shipped. Small chips, fine turnings, and dust from processing may be readily ignitable.
Extinguishing media	
Suitable extinguishing media	Use Class D extinguishing agents on fines, dust or molten metal. Use coarse water spray on chips and turnings.
Unsuitable extinguishing media	DO NOT USE halogenated extinguishing agents on small chips/fines. DO NOT USE water in fighting fires around molten metal. These fire extinguishing agents will react with the burning material.
Protection of firefighters	
Special hazards arising from the substance or mixture	May be a potential hazard under the following conditions: • Dust clouds may be explosive. Even a minor dust cloud can explode violently. Dust accumulation on the floor, ledges and beams can present a risk of ignition, flame propagation and secondary explosions. • Chips, fines and dust in contact with water can generate flammable/explosive hydrogen gas. These gases could present an explosion hazard in confined or poorly ventilated spaces. • Dust and fines in contact with certain metal oxides (e.g., rust, copper oxide). A thermite reaction, with considerable heat generation, can be initiated by a weak ignition source. • Molten metal in contact with water/moisture or certain metal oxides (e.g., rust, copper oxide). Moisture entrapped by molten metal can be explosive. Contact of molten aluminum with certain metal oxides can initiate a thermite reaction. Finely divided metals (e.g., powders or wire) may have enough surface oxide to produce thermite reactions/explosions.
Protective equipment and precautions for firefighters	Fire fighters should wear NIOSH approved, positive pressure, self-contained breathing apparatus and full protective clothing when appropriate.
Fire fighting equipment/instructions	Avoid dust formation.
Explosion data	
Sensitivity to mechanical impact	Not applicable.
Sensitivity to static discharge	Take precautionary measures against static discharges when there is a risk of dust explosion

6. Accidental Release Measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel	Use personal protection recommended in Section 8 of the SDS.
For emergency responders	Avoid generating dust. Use personal protection recommended in Section 8 of the SDS.
Environmental precautions	No special environmental precautions required.
Evacuation procedures	Keep unnecessary personnel away.
Spill or leak procedure	Avoid generating dust clouds. Collect scrap for recycling. If molten: Contain the flow using dry sand or salt flux as a dam. All tooling (e.g., shovels or hand tools) and containers which come in contact with molten metal must be preheated or specially coated, rust free and approved for such use. Allow the spill to cool before remelting as scrap.

Methods and material for containment and cleaning up	No additional information.
Reference to other sections	For personal protection, see section 8 of the SDS. For waste disposal, see section 13 of the SDS.

7. Handling and Storage

Handling	Keep material dry. Avoid generating dust. Avoid contact with sharp edges or heated metal. Hot and cold aluminum are not visually different.
Storage	Store in a dry place.
Requirements for Processes Which Generate Dusts or Fines	If processing of this product generates dust or if extremely fine particulate is generated, obtain and follow the safety procedures and equipment guides contained in Aluminum Association Bulletin F-1 and National Fire Protection Association (NFPA) brochures listed in Section 16. Use non-sparking handling equipment, tools and natural bristle brush. Cover and reseal partially empty containers. Provide grounding and bonding where necessary to prevent accumulation of static charges during metal dust handling and transfer operations (See Section 15). Local ventilation and vacuum systems must be designed to handle explosive dusts. Dry vacuums and electrostatic precipitators must not be used, unless specifically approved for use with flammable/explosive dusts. Dust collection systems must be dedicated to aluminum dust only and should be clearly labeled as such. Do not co-mingle fines of aluminum with fines of iron, iron oxide (rust) or other metal oxides. Do not allow chips, fines or dust to contact water, particularly in enclosed areas. Avoid all ignition sources. Good housekeeping practices must be maintained. Dust accumulation on the floor, ledges and beams can present a risk of ignition, flame propagation and secondary explosions. Do not use compressed air to remove settled material from floors, beams or equipment
Requirements for Remelting of Scrap Material or Ingot	Molten metal and water can be an explosive combination. The risk is greatest when there is sufficient molten metal to entrap or seal off the water. Water and other forms of contamination on or contained in scrap or remelt ingot are known to have caused explosions in melting operations. While the products may have minimal surface roughness and internal voids, there remains the possibility of moisture contamination or entrapment. If confined, even a few drops of water can lead to violent explosions. All tooling, containers, molds and ladles which come in contact with molten metal must be preheated or specially coated, rust free and approved for such use. Any surfaces that may contact molten metal (e.g., concrete) should be specially coated. Drops of molten metal in water (e.g. from plasma arc cutting), while not normally an explosion hazard, can generate enough flammable hydrogen gas to present an explosion hazard. Vigorous circulation of the water and removal of the particles minimize the hazards. During melting operations, the following minimum guidelines should be observed: • Inspect all materials prior to furnace charging and completely remove surface contamination such as water, ice, snow, deposits of grease and oil or other surface contamination resulting from weather exposure, shipment, or storage. • Store materials in dry, heated areas with any cracks or cavities pointed downwards. • Preheat and dry large items adequately before charging into a furnace containing molten metal. This is typically done by use of a drying oven or homogenizing furnace. The drying cycle should bring the metal temperature of the coldest item of the batch to 400°F (200°C) and then hold at that temperature for 6 hours. Thermite explosions have been reported when aluminum alloys were melted in furnaces used for alloying with lead, bismuth or other metals with low melting temperatures. These metals, when added as high purity ingots, can seep through cracks in furnace liners and become oxidized. During subsequent melts in the furnace, molten aluminum can contact these metal oxides resulting in a thermite explosion.

8. Exposure Controls / Personal Protection

Engineering controls	Dust and fumes from processing: Use with adequate explosion-proof ventilation designed to handle particulates to meet the limits listed in Section 8, Exposure Guidelines.
Personal protective equipment	
Eye / face protection	Wear safety glasses with side shields. If molten: Goggles/face shield are recommended.

Skin and body protection	Wear impervious gloves to avoid repeated or prolonged skin contact with residual oils and to avoid any skin injury.
Thermal hazards	Molten metal: When material is heated, wear gloves to protect against thermal burns. Flame retardant protective clothing is recommended.
Respiratory protection	Dust and fumes from processing: Use NIOSH-approved respiratory protection as specified by an Industrial Hygienist or other qualified professional if concentrations exceed the limits listed in Section 8. Suggested respiratory protection: P95.
Environmental exposure controls	No special environmental precautions required.
Hygiene measures	Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and immediately after handling the product. When using, do not eat, drink or smoke.
Recommended monitoring procedures	Follow standard monitoring procedures.

General

Personnel who handle and work with molten metal should utilize primary protective clothing like polycarbonate face shields, fire resistant tapper's jackets, neck shades (snoods), leggings, spats and similar equipment to prevent burn injuries. In addition to primary protection, secondary or day-to-day work clothing that is fire resistant and sheds metal splash is recommended for use with molten metal. Synthetic materials should never be worn even as secondary clothing (undergarments).

Occupational exposure limits

U.S. - OSHA

Components	Type	Value	Form
Aluminum (7429-90-5)	TWA	15 mg/m3	(Total dust)
Chromium (7440-47-3)	TWA	1 mg/m3	
Copper (7440-50-8)	TWA	1 mg/m3	Dust and mist.
		0.1 mg/m3	Fume.
Manganese (7439-96-5)	Ceiling	5 mg/m3	Fume
Silicon (7440-21-3)	TWA	5 mg/m3	Respirable fraction.
		15 mg/m3	(total dust)

Additional components	Type	Value	Form
Chromium (II) compounds (CASNo. Not available)	TWA	0.5 mg/m3	
Chromium (III) compounds (CASNo. Not available)	TWA	0.5 mg/m3	(as Cr)
Chromium (VI) compounds (18540-29-9)	TWA	0.005 mg/m3	(as Cr)
		0.0025 mg/m3	Action (as Cr)
Iron oxide (1309-37-1)	TWA	10 mg/m3	Fume.
Manganese compounds, inorganic (CASNo. Not available)	Ceiling	5 mg/m3	(as Mn) Fume
Zinc oxide (1314-13-2)	TWA	5 mg/m3	(respirable fraction)
		5 mg/m3	(fume)
		15 mg/m3	(total dust)

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Additional components	Type	Value
Chromium (VI) compounds, certain water insoluble forms (CASNo. Not available)	TWA	0.005 mg/m3
Chromium (VI) compounds (18540-29-9)	TWA	0.005 mg/m3

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components	Type	Value	Form
Aluminum (7429-90-5)	PEL	5 mg/m3	Respirable dust.
		15 mg/m3	Total dust.

Additional components	Type	Value	Form
Aluminum oxide (non-fibro us) (1344-28-1)	PEL	5 mg/m3	Respirable fraction.
		15 mg/m3	Total dust.

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Additional components	Type	Value	Form
Magnesium oxide (1309-48-4)	PEL	15 mg/m3	Total particulate.
Nitric oxide (10102-43-9)	PEL	30 mg/m3 25 ppm	
Nitrogen dioxide (10102-44-0)	Ceiling	9 mg/m3 5 ppm	
Ozone (10028-15-6)	PEL	0.2 mg/m3 0.1 ppm	
Zinc oxide (1314-13-2)	PEL	5 mg/m3 5 mg/m3 15 mg/m3	Respirable fraction. Fume. Total dust.

Alcoa

Components	Type	Value	Form
Aluminum (7429-90-5)	TWA	3 mg/m3 10 mg/m3	Respirable fraction Total dust
Manganese (7439-96-5)	TWA	0.05 mg/m3 0.02 mg/m3	Total dust. Respirable fraction.

Additional components	Type	Value	Form
Aluminum oxide (non-fibro us) (1344-28-1)	TWA	3 mg/m3 10 mg/m3	Respirable fraction. Total dust.
Chromium (VI) compounds (18540-29-9)	TWA	0.25 µg/m3	
Manganese compounds, inorganic (CASNo. Not available)	TWA	0.05 mg/m3 0.02 mg/m3	total dust, as Mn respirable fraction, as Mn

ACGIH

Additional components	Type	Value	Form
Aluminum oxide (non-fibro us) (1344-28-1)	TWA	1 mg/m3	Respirable fraction, as Al
Ozone (10028-15-6)	TWA	0.1 ppm 0.08 ppm 0.05 ppm	(light work) (moderate work) (heavy work)

US. ACGIH Threshold Limit Values

Components	Type	Value	Form
Aluminum (7429-90-5)	TWA	1 mg/m3	Respirable fraction.
Chromium (7440-47-3)	TWA	0.5 mg/m3	
Copper (7440-50-8)	TWA	1 mg/m3 0.2 mg/m3	Dust and mist. Fume.
Manganese (7439-96-5)	TWA	0.2 mg/m3	

Additional components	Type	Value	Form
Chromium (III) compounds (CASNo. Not available)	TWA	0.5 mg/m3	
Chromium (VI) compounds, certain water insoluble forms (CASNo. Not available)	TWA	0.01 mg/m3	
Chromium (VI) compounds, water soluble forms (CASNo. Not available)	TWA	0.05 mg/m3	
Iron oxide (1309-37-1)	TWA	5 mg/m3	Respirable fraction.
Magnesium oxide (1309-48-4)	TWA	10 mg/m3	Inhalable fraction.
Manganese compounds, inorganic (CASNo. Not available)	TWA	0.2 mg/m3	

US. ACGIH Threshold Limit Values

Additional components	Type	Value	Form
Nitric oxide (10102-43-9)	TWA	25 ppm	
Nitrogen dioxide (10102-44-0)	STEL	5 ppm	
	TWA	3 ppm	
Ozone (10028-15-6)	TWA	0.05 ppm	
Welding fumes (CASNo. Not available)	TWA	3 mg/m3	Respirable particles.
		10 mg/m3	Inhalable particles.
Zinc oxide (1314-13-2)	STEL	10 mg/m3	Respirable fraction.
	TWA	2 mg/m3	Respirable fraction.

9. Physical & Chemical Properties

Appearance	Silver colored.
Form	Solid.
Odor	Odorless
Odor threshold	Not applicable
pH	Not applicable
Vapor pressure	Not applicable
Vapor density	Not applicable
Boiling point	Not applicable
Melting point/Freezing point	1029.2 - 1209.2 °F (554 - 654 °C)
Solubility (water)	Insoluble
Density	0.097 - 0.099 lb/in3
Relative density	Not determined
Specific gravity	Not applicable
Flash point	Not applicable
Flammability limits in air, upper, % by volume	Not applicable
Flammability limits in air, lower, % by volume	Not applicable
Auto-ignition temperature	Not applicable
Percent volatile	Not applicable

10. Chemical Stability & Reactivity Information

Chemical stability Stable under normal conditions of use, storage, and transportation as shipped.

Conditions to avoid Chips, fines, dust and molten metal are considerably more reactive with the following:
• Water: Slowly generates flammable/explosive hydrogen gas and heat. Generation rate is greatly increased with smaller particles (e.g., fines and dusts). Molten metal can react violently/explosively with water or moisture, particularly when the water is entrapped.
• Heat: Oxidizes at a rate dependent upon temperature and particle size.
• Halogenated compounds: Many halogenated hydrocarbons, including halogenated fire extinguishing agents, can react violently with finely divided or molten aluminum.
• Iron oxide (rust) and other metal oxides (e.g., copper and lead oxides): A violent thermite reaction generating considerable heat can occur. Reaction with aluminum fines and dusts requires only very weak ignition sources for initiation. Molten aluminum can react violently with iron oxide without external ignition source.
• Iron powder and water: Explosive reaction forming hydrogen gas when heated above 1470°F (800°C).
Thermite explosions have been reported when aluminum alloys were melted in furnaces used for alloying with lead, bismuth or other metals with low melting temperatures. These metals, when added as high purity ingots, can seep through cracks in furnace liners and become oxidized. During subsequent melts in the furnace, molten aluminum can contact these metal oxides resulting in a thermite explosion.

Incompatible materials	Chips, fines, dust and molten metal are considerably more reactive with the following: • Acids and alkalis: Reacts to generate flammable/explosive hydrogen gas. Generation rate is greatly increased with smaller particles (e.g., fines and dusts). • Strong oxidizers: Violent reaction with considerable heat generation. Can react explosively with nitrates (e.g., ammonium nitrate and fertilizers containing nitrate) when heated or molten. • Halogenated compounds: Many halogenated hydrocarbons, including halogenated fire extinguishing agents, can react violently with finely divided or molten aluminum.
Hazardous decomposition products	Dry Lubricant: Decomposition can generate: Carbon monoxide, carbon dioxide, aldehydes and partially oxidized hydrocarbons.
Possibility of hazardous reactions	Hazardous polymerization does not occur.

11. Toxicological Information

Health effects associated with ingredients

Aluminum dust/fines and fumes: Low health risk by inhalation. Generally considered to be biologically inert (milling, cutting, grinding).

Silicon (inert dusts): Chronic overexposures: Can cause chronic bronchitis and narrowing of airways.

Manganese dust or fumes: Chronic overexposures: Can cause inflammation of the lung tissues, scarring of the lungs (pulmonary fibrosis), central nervous system damage, Secondary Parkinson's Disease and reproductive harm in males.

Copper dust/mists: Can cause irritation of the eyes, mucous membranes, skin, and respiratory tract. Chronic overexposures: Can cause reduction in the number of red blood cells (anemia), skin abnormalities (pigmentation changes) and hair discoloration.

Chromium dust and fumes: Can cause irritation of eye, skin and respiratory tract. Metallic chromium and trivalent chromium: Not classifiable as to their carcinogenicity to humans by IARC.

Dry Lubricant: Can cause irritation of skin. Skin contact (prolonged or repeated): Can cause dermatitis.

Health effects associated with compounds formed during processing

The following could be expected if welded, remelted or otherwise processed at elevated temperatures

Alumina (aluminum oxide): Low health risk by inhalation. Generally considered to be biologically inert.

Magnesium oxide fumes: Can cause irritation of the eyes and respiratory tract. Acute overexposures: Can cause metal fume fever (nausea, fever, chills, shortness of breath and malaise).

Silica, amorphous: Acute overexposures: Can cause dryness of eyes, nose and upper respiratory tract.

Manganese oxide fumes: Can cause irritation of the eyes, skin, and respiratory tract. Acute overexposures: Can cause metal fume fever (nausea, fever, chills, shortness of breath and malaise).

Copper fume: Can cause irritation of the eyes, mucous membranes, and respiratory tract. Acute overexposures: Can cause metal fume fever (nausea, fever, chills, shortness of breath and malaise).

Iron oxide: Chronic overexposures: Can cause benign lung disease (siderosis). Ingestion: Can cause irritation of gastrointestinal tract, bleeding, changes in the pH of the body fluids (metabolic acidosis) and liver damage.

Zinc oxide fumes: Can cause irritation of upper respiratory tract. Acute overexposures: Can cause metal fume fever (nausea, fever, chills, shortness of breath and malaise).

Hexavalent chromium compounds (Chromium VI): Can cause irritation of eye, skin and respiratory tract. Skin contact: Can cause irritant dermatitis, allergic reactions and skin ulcers. Chronic overexposures: Can cause perforation of the nasal septum, respiratory sensitization, asthma, the accumulation of fluid in the lungs (pulmonary edema), lung damage, kidney damage, lung cancer, nasal cancer and cancer of the gastrointestinal tract. IARC/NTP: Listed as "known to be a human carcinogen" by the NTP. Listed as carcinogenic to humans by IARC (Group 1).

Welding, plasma arc cutting, and arc spray metalizing can generate ozone.
Ozone: Can cause irritation of eyes, nose and upper respiratory tract. Acute overexposures: Can cause shortness of breath, tightness of chest, headache, cough, nausea and narrowing of airways. Effects are reversible on cessation of exposure. Acute overexposures (high concentrations): Can cause respiratory distress, respiratory tract damage, bleeding and the accumulation of fluid in the lungs (pulmonary edema). Effects can be delayed up to 1-2 hours. Additional information: Studies (inhalation) with experimental animals have found genetic damage, reproductive harm, blood cell damage, lung damage and death.

Welding fumes: IARC/NTP: Listed as possibly carcinogenic to humans by IARC (Group 2B). Additional information: In one study, occupational asthma was associated with exposures to fumes from aluminum welding.

Plasma arc cutting of aluminum can generate oxides of nitrogen.
Oxides of nitrogen (NO and NO2): Can cause irritation of eyes, skin and respiratory tract. Acute overexposures: Can cause reduced ability of the blood to carry oxygen (methemaglobin). Can cause cough, shortness of breath, accumulation of fluid in the lungs (pulmonary edema) and death. Effects can be delayed up to 2-3 weeks.
Nitrogen dioxide (NO2): Chronic overexposures: Can cause scarring of the lungs (pulmonary fibrosis).

Components	**Test Results**
Zinc (7440-66-6)	Acute Oral LD50 Rat: 630 mg/kg
Additional components	**Test Results**
Nitrogen dioxide (10102-44-0)	Acute Inhalation LC50 Guinea pig: 30 mg/l 1 Hours
	Acute Inhalation LC50 Rat: 88 mg/l 4 Hours
Iron oxide (1309-37-1)	Acute Oral LD50 Rat: > 10000 mg/kg
Zinc oxide (1314-13-2)	Acute Inhalation LC50 Mouse: > 5.7 mg/l 4 Hours
	Acute Oral LD50 Mouse: 7950 mg/kg
	Acute Oral LD50 Rat: > 5000 mg/kg
	Acute Oral LD50 Rat: > 5 g/kg
	Acute Other LD50 Rat: 240 mg/kg
Aluminum oxide (non-fibrous) (1344-28-1)	Acute Oral LD50 Rat: > 5000 mg/kg

Routes of exposure Eye contact. Skin contact. Inhalation.

Acute effects Dust and fumes from processing: Can cause irritation of the upper respiratory tract. Heating above the melting point releases metallic oxides which may cause metal fume fever by inhalation. The symptoms are shivering, fever, malaise and muscular pain.

Chronic effects Health effects from mechanical processing (e.g., cutting, grinding): Dust and fumes from processing: Chronic overexposures: Can cause reduction in the number of red blood cells (anemia), skin abnormalities (pigmentation changes), scarring of the lungs, (pulmonary fibrosis), secondary Parkinson's disease and reproductive harm in males.

Skin corrosion/irritation Non-corrosive.

Serious eye damage/eye irritation Dust and fume from processing: May be irritating to eyes.

Respiratory system. Irritating to respiratory system.

Sensitization Not classified. Additional health effects from elevated temperature processing (e.g., welded): May cause sensitization by inhalation.

Carcinogenicity None of this product's components are listed by ACGIH, IARC or NTP.

Dust and fumes from welding or elevated temperature processing: Can present a cancer hazard (Hexavalent chromium compounds Welding fume).

ACGIH Carcinogens

Aluminum (CAS 7429-90-5)	A4 Not classifiable as a human carcinogen.
Aluminum oxide (non-fibrous) (CAS 1344-28-1)	A4 Not classifiable as a human carcinogen.
Chromium (CAS 7440-47-3)	A4 Not classifiable as a human carcinogen.
Chromium (III) compounds (CAS CASNo. Not available)	A4 Not classifiable as a human carcinogen.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	A1 Confirmed human carcinogen.
Chromium (VI) compounds, water soluble forms (CAS CASNo. Not available)	A1 Confirmed human carcinogen.
Iron oxide (CAS 1309-37-1)	A4 Not classifiable as a human carcinogen.
Magnesium oxide (CAS 1309-48-4)	A4 Not classifiable as a human carcinogen.

Nitrogen dioxide (CAS 10102-44-0)	A4 Not classifiable as a human carcinogen.
Ozone (CAS 10028-15-6)	A4 Not classifiable as a human carcinogen.

IARC Monographs. Overall Evaluation of Carcinogenicity

Chromium (CAS 7440-47-3)	3 Not classifiable as to carcinogenicity to humans.
Chromium (III) compounds (CAS CASNo. Not available)	3 Not classifiable as to carcinogenicity to humans.
Chromium (VI) compounds (CAS 18540-29-9)	1 Carcinogenic to humans.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	1 Carcinogenic to humans.
Iron oxide (CAS 1309-37-1)	3 Not classifiable as to carcinogenicity to humans.
Silica, amorphous (CAS 69012-64-2)	3 Not classifiable as to carcinogenicity to humans.

US NTP Report on Carcinogens: Known carcinogen

Chromium (VI) compounds (CAS 18540-29-9)	Known To Be Human Carcinogen.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Known To Be Human Carcinogen.

US OSHA Specifically Regulated Substances: Cancer hazard

Chromium (VI) compounds (CAS 18540-29-9)	Cancer hazard.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Cancer hazard.

Teratogenicity	Not classified.
Reproductive toxicity	Dust and fumes from processing: Can present a reproductive hazard for males (Manganese).
Germ cell mutagenicity	Contains no ingredient listed as a mutagen
Synergistic materials	Not classified.
Interactive effects	Asthma, chronic lung disease, skin rashes and secondary Parkinson's disease.
Neurological effects	Not classified. Dust or fume from processing Chronic exposure to breathing low levels of manganese dust or fume over a long period of time can result in "manganism," a disease of the central nervous system similar to Parkinson's Disease, gait impairment, muscle spasms and behavioral changes
Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Not applicable.
Symptoms	Dust and fume from processing: Can cause irritation of the upper respiratory tract. Dust and fume from processing: Chronic overexposures: Can cause reduction in the number of red blood cells (anemia), skin abnormalities (pigmentation changes), scarring of the lungs (pulmonary fibrosis), secondary Parkinson's disease and reproductive harm in males.

12. Ecological Information

Ecotoxicological data

Components	Test Results
Aluminum (7429-90-5)	LC50 Rainbow trout,donaldson trout (Oncorhynchus mykiss): 0.31 mg/l 96 hours
	LC50 Rainbow trout,donaldson trout (Oncorhynchus mykiss): 0.12 mg/l 96 hours
	LC50 Rainbow trout,donaldson trout (Oncorhynchus mykiss): 0.16 mg/l 96 hours
	LC50 Water flea (Daphnia magna): 3.5 mg/l 24 hours
Iron (7439-89-6)	LC50 Channel catfish (Ictalurus punctatus): > 500 mg/l 96 hours
	LC50 Cockle (Cerastoderma edule): 100 - 330 mg/l 48 hours
	LC50 Common shrimp, sand shrimp (Crangon crangon): 33 - 100 mg/l 48 hours
Manganese (7439-96-5)	EC50 Water flea (Daphnia magna): 40 mg/l 48 hours
Chromium (7440-47-3)	EC50 Water flea (Daphnia magna): 0.01 - 0.7 mg/l 48 hours

Components	Test Results
	LC50 Fathead minnow (Pimephales promelas): 10 - 100 mg/l 96 hours
Copper (7440-50-8)	EC50 Water flea (Daphnia obtusa): 0.0076 - 0.026 mg/l 48 hours
	LC50 Bony fish superclass (Osteichthyes): 0.0051 - 0.015 mg/l 96 hours
Zinc (7440-66-6)	EC50 Water flea (Daphnia magna): 2.8 mg/l 48 hours
	LC50 Fathead minnow (Pimephales promelas): 0.211 - 0.269 mg/l 96 hours

Additional components	Test Results
Ozone (10028-15-6)	LC50 Rainbow trout,donaldson trout (Oncorhynchus mykiss): 0.0081 - 0.0106 mg/l 96 hours
Nitrogen dioxide (10102-44-0)	LC50 Tench (Tinca tinca): 19.6 mg/l 96 hours
Zinc oxide (1314-13-2)	LC50 Fathead minnow (Pimephales promelas): 2246 mg/l 96 hours
Aluminum oxide (non-fibrous) (1344-28-1)	

Ecotoxicity No data available for this product.

Environmental effects Not classified as an environmental hazard.

Aquatic toxicity Not expected to be harmful to aquatic organisms.

Persistence and degradability No data is available on the degradability of this product.

13. Disposal Considerations

Disposal instructions Reuse or recycle material whenever possible. If reuse or recycling is not possible, disposal must be made according to local or governmental regulations.

Waste codes RCRA Status: Not federally regulated in the U.S. if disposed of "as is."
RCRA waste codes other than described here may apply depending on use of the product. Status must be determined at the point of waste generation. Refer to 40 CFR 261 or state equivalent in the U.S. TCLP testing is recommended for Chromium. D007: Waste Chromium

Waste from residues / unused products Not applicable.

Contaminated packaging Dispose of in accordance with local regulations.

14. Transport Information

General Shipping Information

Basic shipping requirements:

UN number -
Proper shipping name Not regulated
Hazard class -
Packing group -

General Shipping Notes

• When "Not regulated", enter the proper freight classification, MSDS Number and Product Name onto the shipping paperwork.

Disclaimer

This section provides basic classification information and, where relevant, information with respect to specific modal regulations, environmental hazards and special precautions. Otherwise, it is presumed that the information is not available/not relevant

15. Regulatory Information

Inventory status

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes

Country(s) or region	Inventory name	On inventory (yes/no)*
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	No
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)

Inventory information

Japan - ENCS Inventory: Pure metals are not specifically listed by CAS or ENCS number. The class of compounds for each of these metals is listed on the ENCS inventory.

US federal regulations

In reference to Title VI of the Clean Air Act of 1990, this material does not contain nor was it manufactured using ozone-depleting chemicals.
All electrical equipment must be suitable for use in hazardous atmospheres involving aluminum powder in accordance with 29 CFR 1910.307. The National Electrical Code, NFPA 70, contains guidelines for determining the type and design of equipment and installation which will meet this requirement.

Drug Enforcement Administration (DEA). List 2, Essential Chemicals (21 CFR 1310.02(b) and 1310.04(f)(2)

Not regulated

DEA Essential Chemical Code Number

Not regulated

Drug Enforcement Administration (DEA). List 1 & 2 Exempt Chemical Mixtures (21 CFR 1310.12(c))

Not regulated

DEA Exempt Chemical Mixtures Code Number

Not regulated

US EPCRA (SARA Title III) Section 302 - Extremely Hazardous Spill: Reportable quantity

Nitric oxide (CAS 10102-43-9)	10 LBS
Nitrogen dioxide (CAS 10102-44-0)	10 LBS
Ozone (CAS 10028-15-6)	100 LBS

US EPCRA (SARA Title III) Section 302 - Extremely Hazardous Substance: Threshold Planning Quantity

Nitric oxide (CAS 10102-43-9)	100 LBS
Nitrogen dioxide (CAS 10102-44-0)	100 LBS
Ozone (CAS 10028-15-6)	100 LBS

US EPCRA (SARA Title III) Section 313 - Toxic Chemical: De minimis concentration

Aluminum (CAS 7429-90-5)	1.0 %
Aluminum oxide (non-fibrous) (CAS 1344-28-1)	1.0 %
Chromium (CAS 7440-47-3)	1.0 %
Chromium (III) compounds (CAS CASNo. Not available)	1.0 % N090
Chromium (VI) compounds (CAS 18540-29-9)	0.1 % N090
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	0.1 % N090
Copper (CAS 7440-50-8)	1.0 %
Manganese (CAS 7439-96-5)	1.0 %
Manganese compounds, inorganic (CAS CASNo. Not available)	1.0 % N450
Ozone (CAS 10028-15-6)	1.0 %
Zinc (CAS 7440-66-6)	1.0 %
Zinc oxide (CAS 1314-13-2)	1.0 % N982

US EPCRA (SARA Title III) Section 313 - Toxic Chemical: Listed substance

Aluminum (CAS 7429-90-5)	Listed.
Aluminum oxide (non-fibrous) (CAS 1344-28-1)	Listed.
Chromium (CAS 7440-47-3)	Listed.
Chromium (II) compounds (CAS CASNo. Not available)	Listed. N090
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Listed. N090
Copper (CAS 7440-50-8)	Listed.
Manganese (CAS 7439-96-5)	Listed.
Manganese compounds, inorganic (CAS CASNo. Not available)	Listed. N450
Ozone (CAS 10028-15-6)	Listed.
Zinc (CAS 7440-66-6)	Listed.
Zinc oxide (CAS 1314-13-2)	Listed. N982

US TSCA Section 12(b) Export Notification: Export Notification requirement/De minimis concentration

Chromium (VI) compounds (CAS 18540-29-9)	0.1 % Annual Export Notification required.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	0.1 % Annual Export Notification required.

State regulations

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins.

US - California Proposition 65 - CRT: Listed date/Carcinogenic substance

Chromium (VI) compounds (CAS 18540-29-9)	Listed: February 27, 1987 Carcinogenic.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Listed: February 27, 1987 Carcinogenic.

US - California Proposition 65 - CRT: Listed date/Developmental toxin

Chromium (VI) compounds (CAS 18540-29-9)	Listed: December 19, 2008 Developmental toxin.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Listed: December 19, 2008 Developmental toxin.

US - California Proposition 65 - CRT: Listed date/Female reproductive toxin

Chromium (VI) compounds (CAS 18540-29-9)	Listed: December 19, 2008 Female reproductive toxin.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Listed: December 19, 2008 Female reproductive toxin.

US - California Proposition 65 - CRT: Listed date/Male reproductive toxin

Chromium (VI) compounds (CAS 18540-29-9)	Listed: December 19, 2008 Male reproductive toxin.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Listed: December 19, 2008 Male reproductive toxin.

US - New Jersey RTK - Substances: Listed substance

Aluminum (CAS 7429-90-5)	Listed.
Aluminum oxide (non-fibrous) (CAS 1344-28-1)	Listed.
Chromium (CAS 7440-47-3)	Listed.
Chromium (II) compounds (CAS CASNo. Not available)	Listed.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Listed.
Copper (CAS 7440-50-8)	Listed.
Iron oxide (CAS 1309-37-1)	Listed.
Magnesium (CAS 7439-95-4)	Listed.
Magnesium oxide (CAS 1309-48-4)	Listed.
Manganese (CAS 7439-96-5)	Listed.
Manganese compounds, inorganic (CAS CASNo. Not available)	Listed.
Nitric oxide (CAS 10102-43-9)	Listed.
Nitrogen dioxide (CAS 10102-44-0)	Listed.
Ozone (CAS 10028-15-6)	Listed.
Silica, amorphous (CAS 69012-64-2)	Listed.
Silicon (CAS 7440-21-3)	Listed.
Zinc (CAS 7440-66-6)	Listed.
Zinc oxide (CAS 1314-13-2)	Listed.

US - Pennsylvania RTK - Hazardous Substances: All compounds of this substance are considered environmental hazards

Chromium (CAS 7440-47-3)	LISTED
Copper (CAS 7440-50-8)	LISTED

Manganese (CAS 7439-96-5)	LISTED
Zinc (CAS 7440-66-6)	LISTED

US - Pennsylvania RTK - Hazardous Substances: Listed substance

Aluminum (CAS 7429-90-5)	Listed.
Aluminum oxide (non-fibrous) (CAS 1344-28-1)	Listed.
Chromium (CAS 7440-47-3)	Listed.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Listed.
Copper (CAS 7440-50-8)	Listed.
Iron oxide (CAS 1309-37-1)	Listed.
Magnesium (CAS 7439-95-4)	Listed.
Magnesium oxide (CAS 1309-48-4)	Listed.
Manganese (CAS 7439-96-5)	Listed.
Nitric oxide (CAS 10102-43-9)	Listed.
Nitrogen dioxide (CAS 10102-44-0)	Listed.
Ozone (CAS 10028-15-6)	Listed.
Silica, amorphous (CAS 69012-64-2)	Listed.
Silicon (CAS 7440-21-3)	Listed.
Zinc (CAS 7440-66-6)	Listed.
Zinc oxide (CAS 1314-13-2)	Listed.

US - Pennsylvania RTK - Hazardous Substances: Special hazard

Chromium (CAS 7440-47-3)	Special hazard.
Chromium (VI) compounds (CAS 18540-29-9)	Special hazard.
Chromium (VI) compounds, certain water insoluble forms (CAS CASNo. Not available)	Special hazard.

CERCLA (Superfund) reportable quantity

Copper: 5000
Zinc: 1000
Chromium: 5000

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories	Immediate Hazard - Yes, If particulates/fumes generated during processing Delayed Hazard - Yes, If particulates/fumes generated during processing Fire Hazard - No Pressure Hazard - No Reactivity Hazard - Yes, If molten
Section 302 extremely hazardous substance	No
Section 311 hazardous chemical	No

16. Other Information

Disclaimer	The information in the sheet was written based on the best knowledge and experience currently available.
This data sheet contains changes from the previous version in section(s):	This document has undergone significant changes and should be reviewed in its entirety.
MSDS Status	October 5, 2012: Change(s) in Section: 1, 2, 3,4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16. April 15, 2010: New format. February 09, 2007: Reviewed on a periodic basis in accordance with Alcoa policy. Change(s) in Section: 2, 3, 5, 7, 8, 10, 11, 12, 13, and 15 September 20, 2005: Reviewed on a periodic basis in accordance with Alcoa policy. Change(s) in Section: 1, 2, 3, 4, 7, 8, 10, 11, 12 and 15 June 04, 2002: Change(s) in Section: 1. Origination date: October 17, 1997 Preparer: Jim Perriello, +1-865-977-2051 MSDS System Number: 149475

Other information

• Guide to Occupational Exposure Values 2012, Compiled by the American Conference of Governmental Industrial Hygienists (ACGIH).
• NIOSH Pocket Guide to Chemical Hazards, U.S. Department of Health and Human Services, September 2005.
• expub, Expert Publishing, LLC., www.expub.com,
• Ariel, 3E Company, www.3Ecompany.com
• Aluminum Association's Bulletin F-1, "Guidelines for Handling Aluminum Fines Generated During Various Aluminum Fabricating Operations." The Aluminum Association, 1525 Wilson Boulevard, Suite 600, Arlington, Virginia 22209, www.aluminum.org.
• Aluminum Association, "Guidelines for Handling Molten Aluminum, The Aluminum Association, 1525 Wilson Boulevard, Suite 600, Arlington, Virginia 22209, www.aluminum.org.
• NFPA 484, Standard for Combustible Metals (NFPA phone: 800-344-3555)
• NFPA 654, Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
• NFPA 70, Standard for National Electrical Code (Electrical Equipment, Grounding and Bonding)
• NFPA 77, Standard for Static Electricity

Key/Legend:

ACGIH	American Conference of Governmental Industrial Hygienists
AICS	Australian Inventory of Chemical Substances
CAS	Chemical Abstract Services
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CPR	Cardio-pulmonary Resuscitation
DOT	Department of Transportation
DSL	Domestic Substances List (Canada)
EC	Effective Concentration
ED	Effective Dose
EINECS	European Inventory of Existing Commercial Chemical Substances
ENCS	Japan - Existing and New Chemical Substances
EWC	European Waste Catalogue
EPA	Environmental Protective Agency
IARC	International Agency for Research on Cancer
LC	Lethal Concentration
LD	Lethal Dose
MAK	Maximum Workplace Concentration (Germany) "maximale Arbeitsplatz-Konzentration"
NDSL	Non-Domestic Substances List (Canada)
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
PIN	Product Identification Number
PMCC	Pensky Marten Closed Cup
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SIMDUT	Système d'Information sur les Matières Dangereuses Utilisées au Travail
STEL	Short Term Exposure Limit
TCLP	Toxic Chemicals Leachate Program
TDG	Transportation of Dangerous Goods
TLV	Threshold Limit Value
TSCA	Toxic Substances Control Act
TWA	Time Weighted Average
WHMIS	Workplace Hazardous Materials Information System

m meter, cm centimeter, mm millimeter, in inch,
g gram, kg kilogram, lb pound, µg microgram,
ppm parts per million, ft feet

*** End of MSDS ***

6xxx SERIES ALLOYS WITH ALCOA 951 PRETREATMENT

EMERGENCY OVERVIEW:

WARNING! Non-combustible as supplied. Small chips, fine turnings and dust from processing may be readily ignitable.
Explosion/fire hazards may be present when (See Sections 5, 7 and 10 for additional information):

- Dust or fines are dispersed in air.
- Chips, dust or fines are in contact with water.
- Dust and fines are in contact with certain metal oxides (e.g., rust, copper oxide).
- Molten metal in contact with water/moisture or certain metal oxides (e.g., rust, copper oxide).

Health effects from mechanical processing (e.g., cutting, grinding): Dust from processing: Can cause irritation of the eyes, skin and respiratory tract. Chronic overexposures: Can cause reduction in the number of red blood cells, skin abnormalities, scarring of the lungs, central nervous system damage, secondary Parkinson's disease and reproductive harm in males.

Additional health effects from elevated temperature processing (e.g., welding, melting): Dust and fumes from processing. Acute overexposures: Can cause metal fume fever, the accumulation of fluid in the lungs and reduced ability of the blood to carry oxygen. Chronic overexposures: Can cause scarring of the lungs and lung cancer.

FIRST AID: EYES: Dust and fumes from processing: Rinse eyes with plenty of water or saline for at least 15 minutes. Consult a physician.

SKIN: Dust and fumes from processing: Wash with soap and water for at least 15 minutes. Get medical attention if irritation develops and persists.

INHALATION: Dust and fumes from processing: Remove to fresh air. Check for clear airway, breathing, and presence of pulse. If breathing is difficult, provide oxygen. Loosen any tight clothing on neck or chest. Provide cardiopulmonary resuscitation for persons without pulse or respirations. Consult a physician.

IN CASE OF FIRE: Use Class D extinguishing agents on fines, dust or molten metal. Use coarse water spray on chips and turnings.

DO NOT USE halogenated extinguishing agents on small chips/fines. DO NOT USE water in fighting fires around molten metal. These fire extinguishing agents will react with the burning material.

HANDLING:
Keep material dry. Avoid generating dust. Avoid contact with sharp edges or heated metal. Hot and cold aluminum are not visually different.

STORAGE:
Store in a dry place.

IN CASE OF SPILL:
Avoid generating dust clouds. Collect scrap for recycling.

If molten: Contain the flow using dry sand or salt flux as a dam. All tooling (e.g., shovels or hand tools) and containers which come in contact with molten metal must be preheated or specially coated, rust free and approved for such use. Allow the spill to cool before remelting as scrap.

For additional information See SDS 1008.

USA: Chemtrec: +1-703-527-3887 +1-800-424-9300 (24 Hour Emergency Telephone, multiple languages spoken)

Alcoa Inc., 201 Isabella Street, Pittsburgh, PA 15212-5858 United States +1-412-553-4001 (24 Hour Emergency Telephone, English only)
Alcoa Health and Safety Email: accmsds@alcoa.com Tel: +1-412-553-4649 and Fax: +1-412-553-4822

ALCOA

Material Safety Data Sheet

Bekaert Corporation
1395 South Marietta Parkway
Bldg. 500, Suite 100
Marietta, Georgia 30067

Phone: 770-421-8520
Prepared: 11/08/04
Updated: 09/16/08

MSDS Date: 11/08/04
Product Name: Non-Galvanized and Galvanized Steel Wire and Wire Products (All Grades)
Manufacturer: Bekaert Corporation

I. Product and Company Description

Bekaert Corporation
1881 Bekaert Drive
Van Buren, AR 72956-6801

For Product Information/Emergency:

479-474-5211

Chemical Name or Synonym:

Bezinal ® Wire	Barbed Wire	Dramix ® (Loose & Glued)
Spring Wire	Shape Wire	Strand & Flooded Strand
Galvanized Wire	Field Fence	Low/High Carbon Wire
Welded Mesh	Industrial Steel Wire	Plastic Coated Wire
Oil Tempered Wire	Armapipe ®	Music Wire
Chrome/Silicon Wire	Wire Rope	Standard Alloy Carbon Steel Wire

II. Chemical Composition

Component	CAS #	% Composition
Iron	7439-89-6	Balance
Zinc	7440-66-6	0-8.0
Manganese	7439-96-5	0-1.00
Nickel	7440-02-0	0-0.10
Lead	7439-92-1	0-0.10

III. Hazards Identification

Potential Health Effects:

Note: Steel products in their solid state under normal conditions, do not present an inhalation, ingestion or skin hazard. However, operations resulting in fume or particulate formation such as welding, sawing, brazing, grinding, and machining may present health hazards. Molten steel also is hazardous.

Acute Eye:
Dusts or particulates may cause mechanical irritation including pain, tearing, and redness. Scratching of the cornea can occur if eye is rubbed. Fumes may be irritating. Contact with the heated material may cause thermal burns.

Acute Skin:
Dusts or particulates may cause mechanical irritation due to abrasion. Coated steel may cause skin irritation in sensitive individuals (See section 16 for additional information). Some components in this product are capable of causing an allergic reaction, possibly resulting in burning, itching, and skin eruptions. Contact with heated material may cause thermal burns.

Acute Inhalation:
Dusts may cause irritation of the nose, throat, and lungs. Excessive inhalation of metallic fumes and dusts may result in metal fume fever, an influenza-like illness. It is characterized by a sweet or metallic taste in the mouth, accompanied by dryness and irritation of the throat, cough, shortness of breath, pulmonary edema, general malaise, weakness, fatigue, muscle and joint pains, blurred vision, fever and chills. Typical symptoms last from 12 to 48 hours.

Acute Ingestion:
Not expected to be acutely toxic via ingestion based on the physical and chemical properties of the product. Swallowing of excessive amounts of the dust may cause irritation, nausea, and diarrhea.

Health Effects of Ingredients

Iron: A benign lung condition known as siderosis can result during long-term exposure to iron oxide fumes or dusts. Iron oxide is the result of subjecting iron and alloys to high temperature in the presence of oxygen as in a welding operation.

Zinc: Subjecting zinc or alloys containing zinc to high temperatures in the presence of oxygen (such as occurs during welding) will cause the formation of zinc oxide. Exposure to zinc oxide fumes or dusts can result in a flu-like illness called metal fume fever. Early symptoms may include a sweet or metallic taste in the mouth, dryness and irritation of the throat and coughing. These symptoms may progress to shortness of breath, headaches, fever, chills, muscle aches, nausea, vomiting, weakness, fatigue and profuse sweating. The attack may last 6 to 48 hours and is more likely to occur after a period away from the job.

Manganese dust or fumes: Chronic overexposure can cause inflammation of the lung tissue, scarring of the lungs (pulmonary fibrosis), central nervous system damage, secondary Parkinson's disease and reproductive harm in males. Early symptoms may include weakness in lower extremities, sleepiness, salivation, nervousness, and apathy. In more advance stages, severe muscular incoordination, impaired speech, spastic walking, mask-like facial expression, and uncontrollable laughter may occur. Manganese fumes have also been reported to result in metal fume fever, a flu-like syndrome with symptoms such as dizziness, chills, fever, headache, and nausea. An increased incidence of pneumonia, bronchitis, and pneumonitis has been reported in some worker populations exposed to manganese. Animal studies indicate that manganese exposure may increase susceptibility to bacterial and viral infections.

Nickel: Nickel fumes and dusts are respiratory irritants and may cause a severe pneumonitis. Skin contact with nickel and its compounds may cause an allergic dermatitis. The resulting skin rash is often referred to as "nickel itch." Nickel and its compounds may also produce eye irritation, particularly on the

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Nickel (continued): inner surfaces of the eyelids (i.e., the conjunctive). Animal and/or epidemiology studies have linked nickel and certain nickel compounds to an increased incidence of cancer of the lungs and nasal passages.

III. Hazards Identification

Group 1: The agent is carcinogenic to humans. There is sufficient evidence that a causal relationship existed between exposure to the agent and human cancer.
Group 2B: The agent is possibly carcinogenic to humans. Generally includes agents for which there is limited evidence in the absence of sufficient evidence in experimental animals.

Medical Conditions Aggravated By Exposure to the Product
Asthma, chronic lung disease, and skin rashes.

Possible Residual Lead Effects: Lead intoxication due to inhalation may result from chronic overexposure with symptoms of anemia, insomnia, weakness, constipation, and gastrointestinal disorders. Ingestion may cause nausea and abdominal pain. Lead can aggravate diseases of the blood and blood-forming organs, kidneys, nervous, and possibly reproductive systems. Chronic toxicity results in the potential injury to developing fetus and possible effects on reproduction. Other conditions may include depression of blood-forming activity, kidney disease, and nervous system changes.

IV. First Aid Measures

First Aid Measures for Accidental:

Eye Exposure:
Flush eyes with plenty of water or saline for at least 15 minutes. SEEK MEDICAL ATTENTION.

Skin Exposure:
Wash skin with soap and water for at least 15 minutes. If irritation develops, SEEK MEDICAL ATTENTION.

Inhalation:
Move to fresh air. If not breathing, administer artificial respiration. If breathing is difficult, give oxygen. SEEK MEDICAL ATTENTION.

Ingestion:
Never give fluids or induce vomiting if the victim is unconscious or having convulsions. SEEK MEDICAL ATTENTION.

V. Fire Fighting Measures

Fire Hazard Data:

Flammable Properties
This product does not present fire or explosion hazards as shipped. Small chips, turnings, dust, and fines from processing may be readily ignitable.

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Fire/Explosion

May be potential hazard under the following conditions:

Dust or fines dispersed in the air can be explosive. Even a minor dust cloud can explode violently. Chips, dust or fines in contact with water can generate flammable/explosive hydrogen gas. Hydrogen gas could present an explosion hazard in confined or poorly ventilated spaces. Fines and dust in contact with certain metal oxides (e.g., rust), molten metal in contact with water/moisture or other metal oxides (e.g., rust) and moisture entrapped by molten metal can be explosive.

Extinguishing Media:

Use Class D extinguishing agents on dusts, fines, or molten metal. Use coarse water spray on chips and turnings.

Special Fire Fighting Procedures:

Fire fighters should wear NIOSH approved, positive pressure, self-contained breathing apparatus, and full protective clothing when appropriate. Avoid breathing metal oxide fumes, which may cause metal fume fever.

Unusual Fire and Explosion Hazards:

When heated beyond melting point, metal vapor burns in the air with a bright greenish-yellow flame to produce zinc oxide fumes.

VI. Accidental Release Measures

Cleanup and Disposal of Spill:

Avoid inhalation, eye, or skin contact of dusts by using appropriate precautions outlined in this MSDS (see section 8). Fine turnings and small chips should be swept or vacuumed and placed into appropriate disposable containers. Keep fine dust or powder away form sources of ignition. Scrap should be reclaimed for recycling. Prevent materials from entering drains, sewers, or waterways. Discard any product, residue, disposable container, or liner in full compliance with federal, state, and local regulations.

VII. Handling and Storage

Handling/Storage:

Product should be kept dry. Avoid generating dust. Avoid contact with sharp edges or heated metal. PACKAGES OF THIS MATERIAL MAY CONTAIN EXTREME INTERNAL STRESSES AND STORED MECHANICAL ENERGY. USE STANDARD INDUSTRY PRACTICES AND/OR CONSULT YOUR COMPANY'S SAFETY DEPARTMENT FOR PROPER PROCEDURES FOR HANDLING, OPENING, AND CUTTING.

Requirements for Processes, Which Generate Dusts or Fumes

If processing of these products includes operations where dust or extremely fine particulate is generated, obtain and follow the safety procedures and equipment guides contained in National Fire Protection Association (NFPA) brochure listed in Section 16. Cover and reseal partially empty containers. Use non-sparking handling equipment. Provide grounding and bonding where necessary to prevent accumulation of static charges during dust handling and transfer operations (See Section 16). Local ventilation and vacuum systems must be designed to handle explosive dusts. Dry vacuums and electrostatic precipitators must not be used. Avoid all ignition sources. Good housekeeping practices must by maintained.

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VIII. Exposure Controls/Personal Protection

Engineering Controls
Use with adequate explosion-proof ventilation to meet the limits listed in Section 8.
Personal Protective Equipment
Respiratory Protection
Use NIOSH-approved respiratory protection as specified by an Industrial Hygienist or other qualified professional if concentrations exceed the limits listed in Section 8.

Eye Protection
Wear safety glasses/goggles to avoid eye contact.
Skin Protection
Wear impervious gloves to avoid repeated or prolonged skin contact with residual oils and to avoid any skin injury.
General
Personnel who handle and work with **molten metal** should utilize primary protective clothing like face shields, fire resistant tapper's jackets, leggings, spats, and similar equipment to prevent burn injuries. In addition to primary protection, secondary or day-to-day work clothing that is fire resistant and sheds metal splash is recommended for use with molten metal.
Minimize breathing **oil vapors and mist** from those products coated with oil. Remove oil-contaminated clothing; launder or dry-clean before reuse. Remove oil contaminated shoes and thoroughly clean and dry before reuse. Cleanse skin thoroughly after contact, before breaks and meals, and at the end of the work period. Oil coating is readily removed from skin with waterless hand cleaners followed by a thorough washing with soap and water.

Component	Exposure Limits		
	ACGIH	NIOSH	OSHA-PELs
Iron	ND	ND	ND
Manganese	TWA 0.2 mg/m3	ND	Ceiling 5 mg/m3
Nickel	TWA 1.5 mg/m3	ND	1 mg/m3
Zinc Oxide	TWA 10 mg/m3; (Inhalable particulate matter containing no asbestos and <1% crystalline silica) TWA 5 mg/m3: STEL 10mg/m3	(fume): 5 mg/m3 TWA, 10 mg/m3 STEL REL (total dust): 5 mg/m3 TWA, 15 mg/m3 TWA ceiling (15-min)	Total dust: 15 mg/m3; Respirable fraction: 5.0 mg/m3
Zinc	ND	ND	ND
Lead	TWA 0.05 mg/m3	TWA 0.050 mg/m3: less than 0.1 mg Pb/m3 TWA;	ND

IX. Physical and Chemical Properties

Physical State: Solid
Appearance: Gray Metal
Boiling Point: Not applicable
Solubility in Water: Negligible
pH Level: not applicable
Melting Point: 2800ºF / 621.37 ºF lead
Vapor Density: Not Applicable
Odor: None

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X. Stability and Reactivity

Stability
Stable under normal conditions of use, storage, and transportation as shipped.
Conditions to Avoid
Steel at temperatures above the melting point may liberate fumes containing oxides of iron and alloying elements. Avoid generation of airborne fume.
Hazardous Polymerization
Will not occur
Incompatibility/Materials to Avoid
Reacts with strong acids to form hydrogen gas. Hydrogen peroxide will react violently in contact with lead. (Water reacts violently with molten metals).
Hazardous Decomposition Products
Fumes and certain noxious gases, such as CO, may be produced from welding or burning operations. Lead oxide fumes can result if temperatures exceed the melting point for lead, 621.37 ºF.

XI. Toxicological Information

Health Effects of Ingredients
A: General Product Information
The primary component of this product is iron. Long-term exposure to iron dusts or fumes can result in a condition called siderosis, which is considered a benign pneumoconiosis. Symptoms may include chronic bronchitis, emphysema, and shortness of breath upon exertion. Penetration of iron particles in the skin or eye may cause an exogenous or ocular siderosis, which may be characterized by a red-brown pigmentation of the effected area. Ingestion overexposure to iron may affect the gastrointestinal, nervous, and hematopoietic system and the liver. Iron and steel founding, but not iron oxide, has been listed as potentially carcinogenic by IARC.

When this product is welded, fumes are generated. Welding fumes may be different in composition from the original welding product, with the chief component being ordinary oxides of the metal being welded. Chronic health effects (including cancer) have been associated with the fumes and dusts of individual component metals (see above), and welding fumes as a general category have been listed by IARC as a carcinogen (Group B). There is also limited evidence that welding fumes may cause adverse reproductive and fetal effects. Evidence is stronger where welding materials contain known reproductive toxins, e.g., lead which may be present in the coating material of this product.

Breathing fumes or dusts of this product may result in metal fume fever, which is an illness produced by inhaling metal oxides. These oxides are produced by heating various metals including manganese, zinc and iron. Prolonged exposure to manganese dusts or fumes is associated with “manganism,” a Parkinson-like syndrome characterized by a variety of neurological symptoms including muscle spasms, gait disturbances, tremors, and psychoses.

B. Component Analysis – LD50/LC50
Manganese (7439-96-5)
Oral LD50 Rat: 9gm/kg

Carcinogenicity
A. General Product Information
No information available for product.

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XII. Ecological Information

A: General Product Information
No information available for product.

B: Component Analysis – Ecotoxicity – Aquatic Toxicity
No ecotoxicity data was found for this product's components.
Environmental Fate
No information found for product.

XIII. Disposal Considerations

Disposal Instructions
Reuse or recycle material whenever possible. Material may be disposed of at an industrial landfill.
US EPA Waste Number & Descriptions
A. General Product Information
RCRA Status: Must be determined at time material is disposed. If material is disposed as waste, it must be characterized under RCRA according to 40 CFR, Part 261, or state equivalent in the U.S.
B. Component Waste Numbers
RCRA waste codes other than described under Section A may apply depending on use of product. Refer to 40 CFR 261 or state equivalent in the U.S.

XIV. Transportation Information

US Department of Transportation Shipping Name:
Not regulated

XV. Regulatory Information

US Federal Regulations

Component Analysis
This material contains one or more of the following chemicals required to be identified under SARA Section 302 (40 CFR 355 Appendix A), SARA Section 313 (40 CFR 372.65) and/or CERCLA (40 CFR 302.4)
Manganese (7439-96-5)
SARA 313: form R reporting required for 1.0% de minimis concentration
Nickel (7440-47-3)
SARA 313: form R reporting required for 0.1% de minimis concentration
Zinc (7440-66-6)
SARA 313: form R reporting required for 1.0% de minimis concentration
Lead (7439-92-1)
SARA 313: form R reporting required for 100 pound processing, manufacturing, and otherwise used threshold
SARA 311/312 Physical and Health Hazard Categories:
Immediate (acute) Health Hazard: Yes, if particulates/fumes generated during processing.
Delayed (chronic) Health Hazard: Yes, if particulates/fumes generated during processing.
Fire Hazard: No
Sudden Release of Pressure: No
Reactive: Yes, if molten

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State Regulations

Component Analysis – State
The following components appear on one or more of the following state hazardous substances list:

Component	CA	MA	MI	NJ	PA
Iron	No	No	No	No	No
Manganese	No	Yes	No	Yes	Yes
Nickel	No	Yes	Yes	Yes	Yes
Zinc	No	Yes	Yes	Yes	Yes
Lead	Yes	Yes	Yes	Yes	Yes

The following statement is provided under the California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): WARNING! This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

Other Regulations

A: General Product Information
In reference to Title VI of the Clean Air Act of 1990, this material does not contain nor was it manufactured using ozone-depleting chemicals.

B: Components Analysis – WHMIS IDL
The following components are identified under the Canadian Hazardous Products Act Ingredient Disclosure List:

Component CAS # Minimum Concentration
Manganese 7439-96-5 1% item 974(1077)

XVI.

Other Information

- NFPA 70, Standard for National Electric Code (Electrical Equipment, Grounding and Bonding)
- NFPA 77, Standard for Static Electricity
- Guide to Occupational Exposure Values-1999, Compiled by the American Conference of Governmental Industrial Hygienists (ACGIH).
- Documentation of the Threshold Limit Values and Biological Exposure Indices, Sixth Edition, 1991, Compiled by the American Conference of Governmental Industrial Hygienists, Inc. (ACGIH).
- NIOSH Pocket Guide to Chemical Hazards, U.S. Department of Health and Human Services, June 1994
- Dangerous Properties of Industrial Materials, Sax, N.Irving, Van Nostrand Reinhold Co., Inc. 1984.
- Patty's Industrial Hygiene and Toxicology: Volume II: 4th ed., 1994, Patty, F. A.; edited by Clayton, G.D.and Clayton, F.E.: New York: John Wiley & Sons, Inc.
- TOMES CPS™, MICROMEDEX, Inc., 1999

Material Safety Data Sheet

Bekaert Corporation
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Phone: 770-421-8520
Prepared: 11/08/04
Updated: 09/16/08

Key Legend Information:

ACGIH American Conference of Governmental Industrial Hygienists
AICS Australian Inventory of Chemical Substances
CAS Chemical Abstract Service
CERCLA Comprehensive Environmental Response Compensation, and Liability Act
CFR Code of Federal Regulation
CPR Cardio-Pulmonary Resuscitation
DOT Department of Transportation
DSL Domestic Substance List (Canada)
EINECS European Inventory of Existing Commercial Chemical Substance
EPA Environmental Protection Act
IARC International Agency for Research on Cancer
LC_{50} Lethal concentration (50 percent kill)
LC_{Lo} Lowest published lethal concentration
LD_{50} Lethal dose (50 percent kill)
LD_{Lo} Lowest published lethal dose
LFL Lower Flammable Limit

MITI Ministry of International Trade & Industry
NFPA National Fire Protection Association
m Meter
mg milligram
ml, ML milliliter
mm millimeter
n.o.s. not otherwise specified

NIOSH National Institute for Occupational Safety and Health
NTP National Toxicology Program
OEL Occupational Exposure Limit
OSHA Occupational Safety and Health Administration
PEL Permissible Exposure Limit
RCRA Resource Conservation and Recovery Act
SARA Superfund Amendments and Reauthorization Act
STEL Short Term Exposure Limit
TCLP Toxic Chemicals Leachate Program
TDG Transportation of Dangerous Goods
TSCA Toxic Substance Control Act
TWA Time Weighted Average
UFL Upper Flammable Limit
atm atmosphere
cm centimeter
g, gm gram
in inch

kg kilogram
lb pound
ppb parts per billion
ppm part s per million
psia pounds per square inch absolute
u micron
ug microgram

The information contained herein is based on the data available to us and is believed to be correct. However Bekaert Corporation makes no warranty, expressed or implied regarding the accuracy of this data or the results to be obtained from the use thereof.

PLEXIGLAS® G ACRYLIC SHEET

1. PRODUCT AND COMPANY IDENTIFICATION

Company

Arkema Inc.
2000 Market Street
Philadelphia, Pennsylvania 19103

Altuglas International

Customer Service Telephone Number: (800) 523-1532
(Monday through Friday, 8:30 AM to 5:30 PM EST)

Emergency Information

Transportation: CHEMTREC: (800) 424-9300
(24 hrs., 7 days a week)
Medical: Rocky Mountain Poison Center: (303) 623-5716
(24 hrs., 7 days a week)

Product Information

Product name: PLEXIGLAS® G ACRYLIC SHEET
Synonyms: Not available
Molecular formula: Not available
Chemical family: acrylic copolymer
Product use: Special applications, in general

2. HAZARDS IDENTIFICATION

Emergency Overview

Color: clear
Physical state: solid
Form: sheets
Odor: odourless

CAUTION!
PROCESSING MAY RELEASE VAPORS AND/OR FUMES WHICH CAUSE EYE, SKIN AND RESPIRATORY TRACT IRRITATION.

Potential Health Effects

Primary routes of exposure:
Inhalation and skin contact.

Signs and symptoms of acute exposure:
High molecular weight polymer. The product, in the form supplied, is not anticipated to produce significant adverse human health effects. Product dust may be irritating to eyes, skin and respiratory system. Effects due to processing releases: Irritating to eyes, respiratory system and skin. Inhalation of fume may cause flu-like symptoms. (severity of effects depends on extent of exposure) Prolonged or repeated exposure may cause: headache, drowsiness, nausea, weakness.

Remarks:

Handle in accordance with good industrial hygiene and safety practice. (sheets) Secondary operations, such as grinding, sanding or sawing, can produce dust which may present a respiratory hazard. This product may release fume and/or vapor of variable composition depending on processing time and temperature.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	CAS-No.	Wt/Wt	OSHA Hazardous
Polymethyl methacrylate copolymers	Proprietary*	99 - 100 %	N

The substance(s) marked with a "Y" in the Hazard column above, are those identified as hazardous chemicals under the criteria of the OSHA Hazard Communication Standard (29 CFR 1910.1200).

*The specific chemical identity is withheld because it is trade secret information of Arkema Inc.

While this material is not classified as hazardous under Federal OSHA regulations, this MSDS contains valuable information critical to the safe handling and proper use of this product. This MSDS should be retained and available for employees and other users of this product.

4. FIRST AID MEASURES

Inhalation:
If inhaled, remove to fresh air.

Skin:
In case of contact, immediately flush skin with plenty of water. If molten polymer gets on the skin, cool rapidly with cold water. Do not peel solidified product off the skin. Obtain medical treatment for thermal burns. Remove material from clothing. Wash clothing before reuse.

Eyes:
Immediately flush eye(s) with plenty of water. Obtain medical treatment for thermal burns.

Ingestion:
If swallowed, DO NOT induce vomiting. Get medical attention. Never give anything by mouth to an unconscious person.

5. FIRE-FIGHTING MEASURES

Flash point not applicable

Auto-ignition temperature: 860 °F (460 °C)

Lower flammable limit (LFL): not applicable

Upper flammable limit (UFL): not applicable

Extinguishing media (suitable):
Dry chemical, water spray, carbon dioxide, foam

Protective equipment:

Fire fighters and others who may be exposed to products of combustion should wear full fire fighting turn out gear (full Bunker Gear) and self-contained breathing apparatus (pressure demand / NIOSH approved or equivalent).

Further firefighting advice:
Fire fighting equipment should be thoroughly decontaminated after use.

Fire and explosion hazards:
Heated material can form flammable vapors with air.

6. ACCIDENTAL RELEASE MEASURES

In case of spill or leak:
Pick up and transfer to properly labelled containers. Consult a regulatory specialist to determine appropriate state or local reporting requirements, for assistance in waste characterization and/or hazardous waste disposal and other requirements listed in pertinent environmental permits.

7. HANDLING AND STORAGE

Handling

General information on handling:
Avoid breathing processing fumes or vapors.
Avoid breathing dust.
Handle in accordance with good industrial hygiene and safety practices.
These practices include avoiding unnecessary exposure and removal of material from eyes, skin and clothing.

Storage

General information on storage conditions:
Avoid extreme temperatures.

Storage incompatibility – General:
Store away from sources of heat and light.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Airborne Exposure Guidelines:

2-Propenoic acid, 2-methyl-, methyl ester (80-62-6)

US. ACGIH Threshold Limit Values

Time Weighted Average (TWA):	50 ppm
Short Term Exposure Limit (STEL):	100 ppm

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

PEL:	100 ppm (410 mg/m3)

Only those components with exposure limits are printed in this section. Limits with skin contact designation above have skin contact effect. Air sampling alone is insufficient to accurately quantitate exposure. Measures to prevent significant cutaneous absorption may be required. Limits with a sensitizer designation above mean that exposure to this material may cause allergic reactions.

Engineering controls:
Investigate engineering techniques to reduce exposures below airborne exposure limits. Provide ventilation if necessary to control exposure levels below airborne exposure limits (see above). If practical, use local mechanical exhaust ventilation at sources of air contamination such as open process equipment.

Respiratory protection:
Avoid breathing processing fumes or vapors. Avoid breathing dust. Where airborne exposure is likely or airborne exposure limits are exceeded (if applicable, see above), use NIOSH approved respiratory protection equipment appropriate to the material and/or its components and substances released during processing. Consult respirator manufacturer to determine appropriate type equipment for a given application. Observe respirator use limitations specified by NIOSH or the manufacturer. For emergency and other conditions where there may be a potential for significant exposure or where exposure limit may be significantly exceeded, use an approved full face positive-pressure, self-contained breathing apparatus or positive-pressure airline with auxiliary self-contained air supply. Respiratory protection programs must comply with 29 CFR § 1910.134.

Skin protection:
Processing of this product releases vapors or fumes which may cause skin irritation. Minimize skin contamination by following good industrial hygiene practice. Wearing protective gloves is recommended. Wash hands and contaminated skin thoroughly after contact with processing fumes or vapors. Wash thoroughly after handling.

Eye protection:
Processing of this product releases vapors or fumes which may cause eye irritation. Use good industrial practice to avoid eye contact. Where eye contact may be likely, wear chemical goggles and have eye flushing equipment available.

9. PHYSICAL AND CHEMICAL PROPERTIES

Color:	clear
Physical state:	solid
Form:	sheets
Odor:	odourless
pH:	not applicable
Density:	not applicable
Vapor pressure:	not applicable
Vapor density:	not applicable
Boiling point/boiling range:	not applicable
Freezing point:	not applicable

Melting point/range: not applicable

Solubility in water: insoluble

% Volatiles: 0 %

10. STABILITY AND REACTIVITY

Stability:
The product is stable under normal handling and storage conditions

Hazardous reactions:
Hazardous polymerization does not occur.

Materials to avoid:
None under normal conditions of use.

Conditions / hazards to avoid:
Avoid flames, welding arcs, potential ignition sources, or other high temperature sources which induce thermal decomposition.

Hazardous decomposition products:
Thermal decomposition may yield acrylic monomers. Thermal decomposition begins to generate monomer vapor at >570F (>300 C).

11. TOXICOLOGICAL INFORMATION

Data on this material and/or its components are summarized below.

Data for Polymethyl methacrylate copolymers (Proprietary)

Acute toxicity

Oral:
Practically nontoxic. (rat) LD50 = 8,000 mg/kg. (similar material)

Genotoxicity

Assessment in Vitro:
No genetic changes were observed in laboratory tests using: bacteria, human cells

Genotoxicity

Assessment in Vivo:
No genetic changes were observed in laboratory tests using: animals

Other information
Biocompatibility testing for this polymer or its extracts has generally shown that the material is inert.

Human experience

Skin contact:
Skin: Irritant but not a sensitizer. Mechanical irritation. (studied using human volunteers)

12. ECOLOGICAL INFORMATION

Chemical Fate and Pathway
No data are available.

Ecotoxicology
No data are available.

13. DISPOSAL CONSIDERATIONS

Waste disposal:
Where possible recycling is preferred to disposal or incineration. If recycling is not an option, incinerate or dispose of in accordance with federal, state, and local regulations. Pigmented, filled and/or solvent laden product may require special disposal practices in accordance with federal, state and local regulations. Consult a regulatory specialist to determine appropriate state or local reporting requirements, for assistance in waste characterization and/or hazardous waste disposal and other requirements listed in pertinent environmental permits. Note: Chemical additions to, processing of, or otherwise altering this material may make this waste management information incomplete, inaccurate, or otherwise inappropriate. Furthermore, state and local waste disposal requirements may be more restrictive or otherwise different from federal laws and regulations.

14. TRANSPORT INFORMATION

US Department of Transportation (DOT): not regulated

International Maritime Dangerous Goods Code (IMDG): not regulated

15. REGULATORY INFORMATION

Chemical Inventory Status

EU. EINECS	EINECS	Does not conform
US. Toxic Substances Control Act	TSCA	The components of this product are all on the TSCA Inventory.
Australia. Industrial Chemical (Notification and Assessment) Act	AICS	Conforms to
Canada. Canadian Environmental Protection Act (CEPA). Domestic Substances List (DSL). (Can. Gaz. Part II, Vol. 133)	DSL	All components of this product are on the Canadian DSL list.
Japan. Kashin-Hou Law List	ENCS (JP)	Conforms to
Korea. Toxic Chemical Control Law (TCCL) List	KECI (KR)	Conforms to

Philippines. The Toxic Substances and Hazardous and Nuclear Waste Control Act	PICCS (PH)	Conforms to
China. Inventory of Existing Chemical Substances	IECSC (CN)	Conforms to
New Zealand. Inventory of Chemicals (NZIoC), as published by ERMA New Zealand	NZIOC	Does not conform

United States – Federal Regulations

SARA Title III – Section 302 Extremely Hazardous Chemicals:
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA Title III - Section 311/312 Hazard Categories:
No SARA Hazards

SARA Title III – Section 313 Toxic Chemicals:
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - Reportable Quantity (RQ):

The components in this product are either not CERCLA regulated, regulated but present in negligible concentrations, or regulated with no assigned reportable quantity.

OSHA Regulated Carcinogens (NTP, IARC, OSHA Listed):

NTP:
No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

IARC:
No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

OSHA:
No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

United States – State Regulations

Massachusetts Right to Know

No components are subject to the Massachusetts Right to Know Act.

New Jersey Right to Know

No components are subject to the New Jersey Right to Know Act.

Pennsylvania Right to Know

Chemical Name	CAS-No.
Polymethyl methacrylate copolymers	Proprietary

California Prop. 65
This product does not contain any chemicals known to the State of California to cause cancer, birth defects, or any other reproductive defects.

16. OTHER INFORMATION

Latest Revision(s):

Revised Section(s):	Updated Section 2 and 9
Reference number:	000000036586
Date of Revision:	10/29/2008
Date Printed:	10/29/2008

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