SECTION 6 - TECHNOLOGY SAFETY DATA SHEET

TECHNOLOGY SAFETY DATA SHEET
REMOTELY OPERATED VEHICLE WITH CARBON DIOXIDE BLASTING
(CONCRETE)

<table>
<tr><th colspan="2">SECTION 1: TECHNOLOGY IDENTITY</th></tr>
<tr><td rowspan="3">Manufacturer’s Name and Address:

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SECTION 2: PROCESS DESCRIPTION

$ROVCO_2$ consists of the following integrated subsystems:

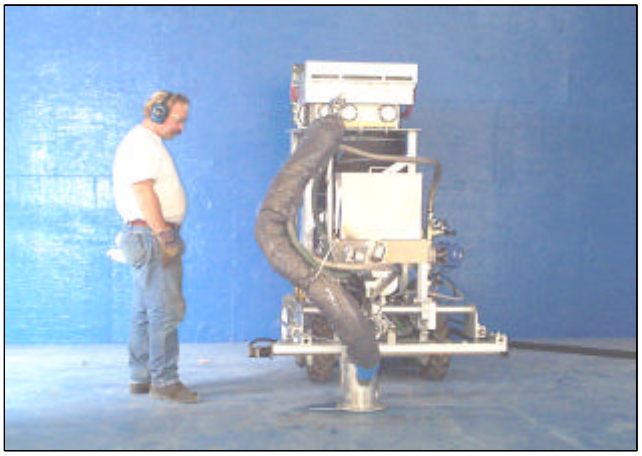
- the remotely operated vehicle (ROV);
- the carbon dioxide blasting system (cryogenesis system);
- the CO_2 Orthogonal Translational End Effector (COYOTEE);
- the Operator Control Unit Subsystem (OCUS);
- the tether management subsystem (TMS); and
- the vacuum/filtration/containment subsystem (VFCS).

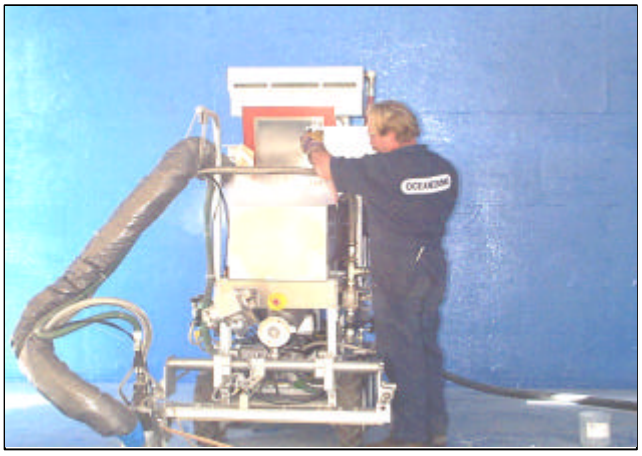
Additionally, the system needs to be supported with an industrial compressor to provide the compressed air needed to propel the grit against the floor. The compressor used during the FIU demonstration was diesel powered and maintained air pressure between 250 and 300 psi at the unit. The compressor was mounted on a flat-bed tractor trailer. Also located on the trailer was a cooling unit and a dryer. The air passed trough the cooler because hot air will destroy the dessicant in the dryer. The air had to be dried because moisture in the air will quickly freeze when it contacts the dry ice, forming an ice dam that can halt the operation. The air was delivered at between 150 and 180 psi at the $ROVCO_2$ blasting unit.

The $ROVCO_2$ system provides the marked safety advantage of being able to perform high hazard work remotely, eliminating or reducing exposures to workers. The blasting system has two television cameras mounted on it and is connected by a tether to the control station where the operator can adjust the speed of the vehicle as well as the operation of the blasting nozzle. The frozen carbon dioxide (dry ice) pellets used for blasting sublimate into gas, thereby eliminating one of the greatest sources of hazardous waste in blasting operations: the grit itself. $ROVCO_2$ operates under a constant vacuum so the grit is drawn away and the air passes through prefilters and then a high efficiency filter before being released to the atmosphere. These filter are an integrated part of the unit.

For this demonstration, dry ice had to be manually added to $ROVCO_2$. The attendant shovelled dry ice from a large container into a bucket that he then dumped into the hopper at a height of 49 inches on the side of $ROVCO_2$.

SECTION 3: PROCESS DIAGRAMS





SECTION 4: CONTAMINANTS AND MEDIA

The blasting operation creates a minimum amount of dust if the inflatable seal around the blasting head in maintained and the vacuum pressure is okay. The dust generated may contain coating, subsurface, and blasting media contaminants. These will need to be identified by the site characterization prior to the beginning of the job. A monitoring plan will need to be developed on a site-by-site job-by-job basis. The blasting media for ROVCO_2 is dry ice which is extremely cold (-109 degrees F.) solid carbon dioxide. It can damage eyes and skin and at room temperature becomes carbon dioxide gas which can force out oxygen from tight spaces creating the risk of asphyxiation.

SECTION 5: ASSOCIATED SAFETY HAZARDS

Probability of Occurrence of Hazard:

1 Hazard may be present but not expected over background level
2 Some level of hazard above background level known to be present
3 High hazard potential
4 Potential for imminent danger to life and health

A. ELECTRICAL (LOCKOUT/TAGOUT)	RISK RATING:2

The technology has the potential to present electrical hazards. Assure proper grounding and use of ground fault circuit interrupters on all equipment. Compliance with applicable electrical standards and codes and lockout/tagout procedures must be followed to assure the safety of personnel.

B. FIRE AND EXPLOSION	RISK RATING: 1

Normal fire and explosion hazards in association with electrical powered equipment. The equipment is not intrinsically safe and could not be used in a potentially explosive atmosphere.

C. CONFINED SPACE ENTRY	RISK RATING: N/A

Not part of this technology.

D. MECHANICAL HAZARDS	RISK RATING: 2

ROVCO_2 has moving parts which may cause injury from pinch points. The auger for feeding dry ice pellets is of particular concern. It is not readily accessible at the bottom of the hopper, but it does pose the risk of catching fingers if someone reaches into it.

E. PRESSURE HAZARDS	RISK RATING: 3

The air lines and the high pressure air present a potential struck-by hazard if they were to rupture or disconnect.

SECTION 5: ASSOCIATED SAFETY HAZARDS CONTINUED	
F. TRIPPING AND FALLING	RISK RATING: 2
The air line, electrical line, and cable from the control unit present tripping hazards in the area where they are being used.	
G. LADDERS AND PLATFORMS	RISK RATING: N/A
Not part of this technology.	
H. MOVING VEHICLES	RISK RATING: 4
During start-up, if the “Auto/Move” switch on the control console is in the auto position the unit can move forward immediately. It is critical to check this setting before starting and to train workers to stay back from the unit during startup. The presence of multiple pieces of mobile equipment (which may be needed to unload and load technology) in relationship to a small area of operation may pose a significant danger. Sufficient warning devices such as horns, bells, lights, and back up alarms should be utilized. Personnel should be trained to work with and around moving equipment.	
I. BURIED UTILITIES, DRUMS, AND TANKS	RISK RATING: N/A
Not part of this technology.	
J. PROTRUDING OBJECTS	RISK RATING: N/A
Not part of this technology.	
K. GAS CYLINDERS	RISK RATING: N/A
Not part of this technology.	
L. TRENCHING AND EXCAVATIONS	RISK RATING: N/A
Not part of this technology.	
M. OVERHEAD LIFTS	RISK RATING: 3
Unloading and loading of technology may require overhead lifts or the use of a forklift. Proper precautions indicated.	
N. OVERHEAD HAZARDS	RISK RATING: 2
Would only be present if a crane were required to unload or load equipment.	

SECTION 6: ASSOCIATED HEALTH HAZARDS	
A. INHALATION HAZARD	RISK RATING: 3
Dust exposure during operation is well controlled by the local exhaust but respiratory protection may be needed, depending on the toxicity of the contaminant. Of particular concern is the build-up of carbon dioxide gas from the dry ice. In tight areas this could reduce the oxygen levels to a dangerous point. The carbon dioxide levels should be measured routinely during any operation of ROVCO_2.	
B. SKIN ABSORPTION	RISK RATING: 3

SECTION 6: ASSOCIATED HEALTH HAZARDS	
Dry ice is extremely cold and can damage the skin and eyes from direct contact after a very short period. Thick gloves, eye protection, long sleeve shirt and pants should be worn when working with dry ice to prevent contact with bare skin and eyes. limited.	
C. HEAT STRESS	RISK RATING: 2
The need to wear PPE has the potential to increase the heat stress load on any worker, however, the ROVCO_2 blasting system operates remotely which greatly reduces the amount of physical labor needed and the length of time workers need to wear protective garments.	
D. NOISE	RISK RATING: 3
Noise exposure is excessive during the operation of ROVCO_2. Noise monitoring has shown values well in excess of the OSHA PEL and ACGIH TLV for an 8-hour work shift. Workers should wear hearing protection, preferably ear muffs, whenever working around the blasting unit or the compressor.	
E. NON-IONIZING RADIATION	RISK RATING: N/A
Not part of this technology.	
F. IONIZING RADIATION	RISK RATING: N/A
Not part of this technology.	
G. COLD STRESS	RISK RATING: 1
Technology does not produce a hazard but ambient conditions need to be considered.	
H. ERGONOMIC HAZARDS	RISK RATING: 2
There is potential for ergonomic stressors from the ROVCO_2 blasting system but the remote operation greatly reduces the potential. Loading and unloading the equipment presents standard lifting hazards. Shovelling, screening, and carrying dry ice presents ergonomic risks that will hopefully be reduced through further automation of the process. Dumping 5 gallon buckets of dry ice (approx. 40 pounds) into a hopper is not only physically stressful, it regularly brings workers into contaminated environments. The control panel needs to be reconsidered to make the controls easier to use. The emergency stop should be more obvious on the control panel and on the vehicle, too.	
I. OTHER	RISK RATING: 3
Remote operation poses the risk that workers entering the operating space of ROVCO_2 will not be seen on either of the two cameras mounted on the unit. The operating space for ROVCO_2 needs to be clearly marked with warning signs and workers need to be trained to inform the operator when they will be entering the space.	

SECTION 7: PHASE ANALYSIS

A. START-UP

The set-up/start-up phase presents several hazards including struck-by/caught between hazards, pinch points, slips/trips/falls, muscular/back injury, and electrical hazards.

B. OPERATION

The operational phase presents several hazards including potential exposure to contaminants, hazards of dry ice, noise, hazards associated with the air lines, muscular/back injury, difficult communication due to remote operation, and electrical hazards. Removing the drum from ROVCO_2 when full of waste from the blasting operation involves potential exposure to contaminants as well as lifting hazards.

C. MAINTENANCE

The maintenance phase presents several hazards including pinch points, slips/trips/falls, struck-by/caught between, muscular/back injury, electrical hazards, exposure to contaminants, and accidental activation of moving parts. Removing the roughing filters and the HEPA filter involve potential exposure to contaminants.

D. DECOMMISSIONING

The decommissioning phase presents several hazards including exposure to the contaminants, pinch points, slips/trips/falls, and muscular/back injury.

SECTION 8: HEALTH AND SAFETY PLAN REQUIRED ELEMENTS

A. AIR MONITORING

Operating ROVCO_2 produces little dust but does results in elevated levels of carbon dioxide. An air monitoring plan will need to be developed for the contaminants such as radionuclides that will be removed from the floor surface as well as the carbon dioxide. Noise generated is excessive. A noise monitoring plan is essential.

B. WORKER TRAINING

Training that would apply in this case may include but not be limited to: HAZWOPER (Hazardous Waste Operations and Emergency Response), HAZCOM (Hazard Communication), Respiratory Protection, Hearing Conservation, Ergonomics (proper lifting, bending, stooping, kneeling), Heat Stress (learning to recognize signs and symptoms), Personal Protective Equipment, Emergency Response/Bloodborne Pathogens, Lockout/Tagout, Hand Signal Communication, Construction Safety (OSHA 500), and/or General Industry Safety (OSHA 501).

C. EMERGENCY RESPONSE

Emergency response planning for a site needs to assure adequate coverage for hazards described in the TSDS. Having at least one worker per shift trained in CPR and first aid is recommended.

D. MEDICAL SURVEILLANCE

Evaluation of personnel's general health with emphasis on the back and

SECTION 8: HEALTH AND SAFETY PLAN REQUIRED ELEMENTS
cardiovascular/respiratory system is recommended. Medical surveillance may be required by OSHA standards such as HAZWOPER and the noise standard. The latter would require initial and annual audiograms.
E. INFORMATIONAL PROGRAM
Workers must be trained in specific operation of equipment before use. A program to train workers to safely operate and maintain ROVCO_2 is under development by the Operating Engineers National Hazmat Program. Copies can be ordered

SECTION 9: COMMENTS AND SPECIAL CONSIDERATIONS
Only personnel who have been adequately trained in the operation of ROVCO_2 and associated hazards should be permitted to operate the system. Consideration needs to be given to the compatibility of the PPE with specific contaminants and the exposure level of the contaminants.