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## 7.0 FIGURES

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**Figure 1: Machined End Connections On Casing**



**Figure 2: Measuring Resin Components And Wiper Plug Insert**



**Figure 3: Casing Preparation And placing Wiper Plug Inserts**



Figure 4: Placing Resin Into Casing And The Casing Stub With Aluminum Centralizer

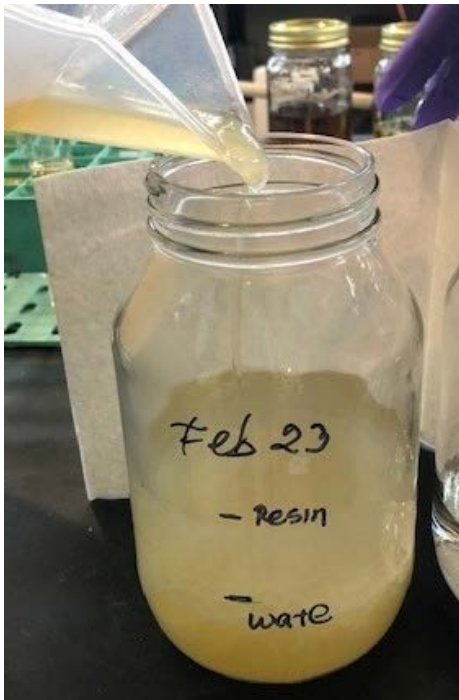


Figure 5: Pouring Resin Into Container With Water





Figure 6: Quizix Machine



Figure 7: Resin Curing In Various Fluids In A Paraffin Lined Container And An Empty Container

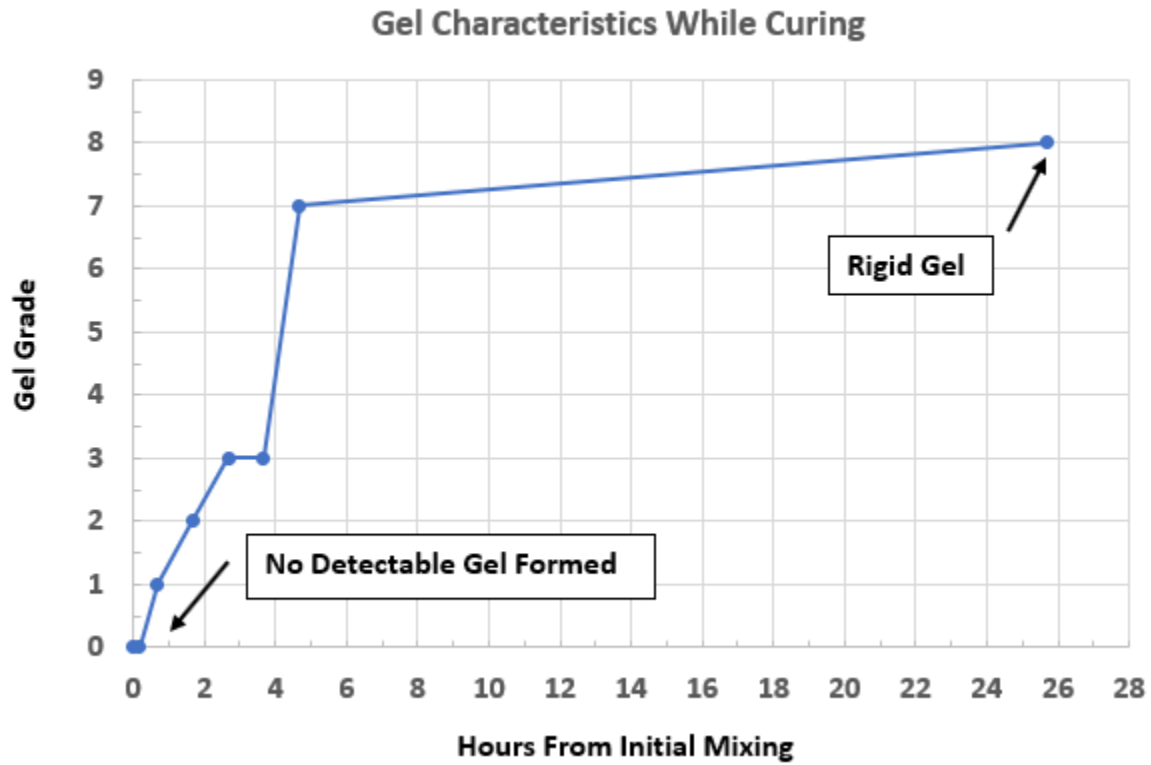


Figure 8: Resin Gel Characteristics While Curing



Figure 9: Resin Samples With And Without Voids



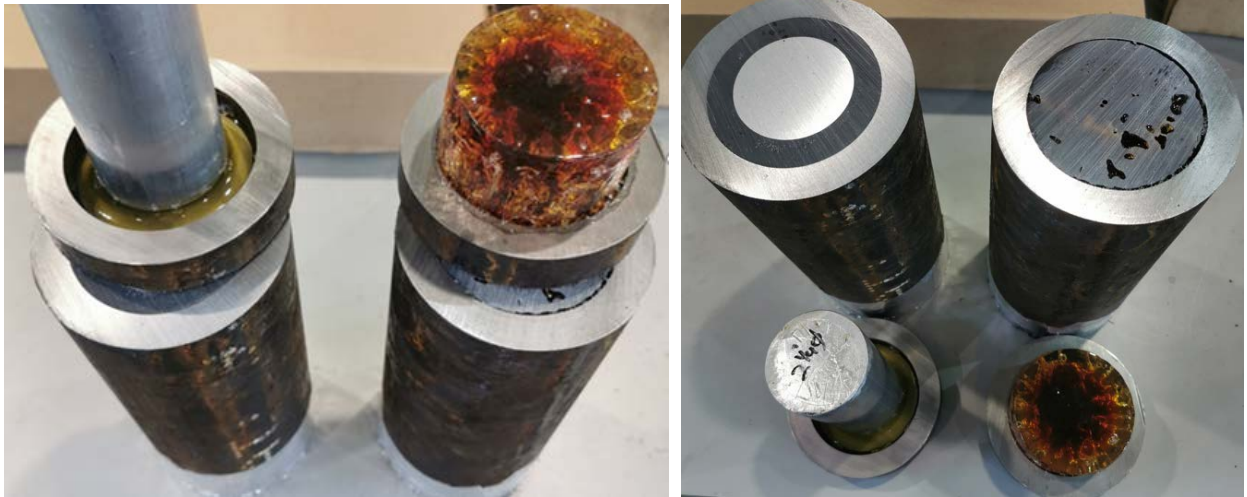


Figure 10: Resin Cured In Water With Voids And Some Top Foam

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Figure 11: Resin Curing / Extruding from Casing Stub and Casing Stub With Centralizer



**Figure 12: Cured Resin In Casing Stubs in Preparation For Shear Adhesion Testing**



**Figure 13: Casing Stubs With Resin Prepared For Shear-Adhesion Testing**



**Figure 14: Intron Satec 600 DX Load Frame With a Casing Stub in Position**

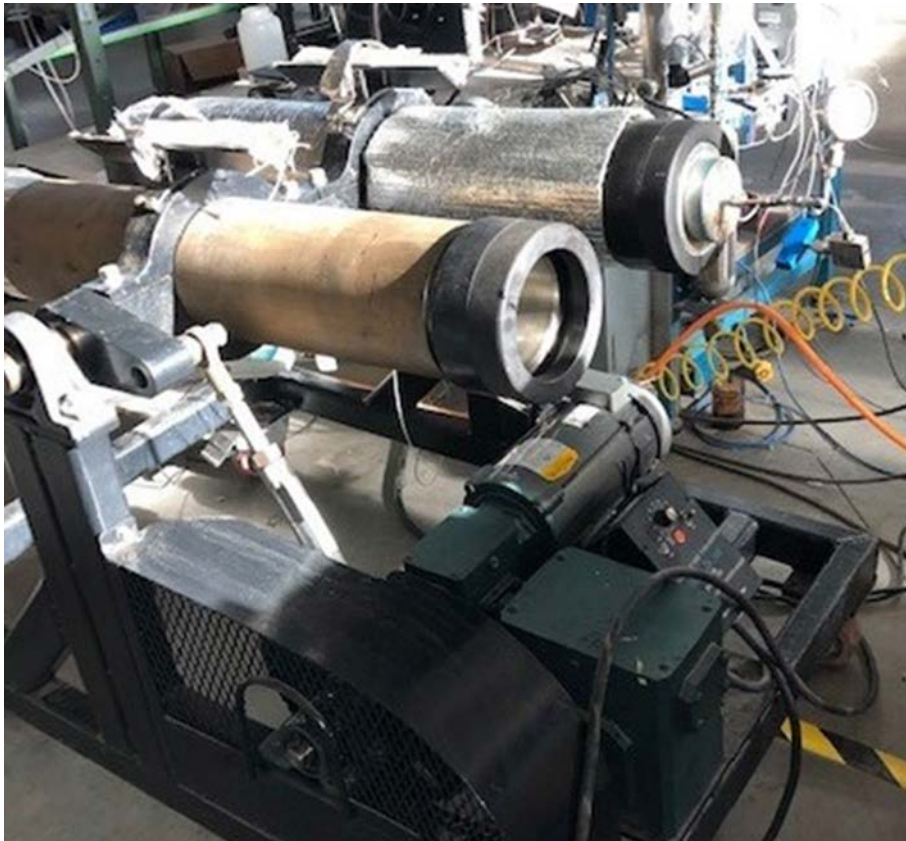


**Figure 15: Resin With Centralizer Pushed Out Of Short Casing Stub**





**Figure 16: Resin With No Centralizer Pushed Out Of Casing Stub**



**Figure 17: Endurance Testing Machine**



Figure 18: Resin, Class G Cement & J55 Steel Samples Before Endurance Testing



Figure 19: Resin, Class G Cement & J55 Steel Samples At 90 Days Of Endurance Testing





Figure 20: Resin, Class G Cement & J55 Steel Samples After 194 Days Of Endurance Testing

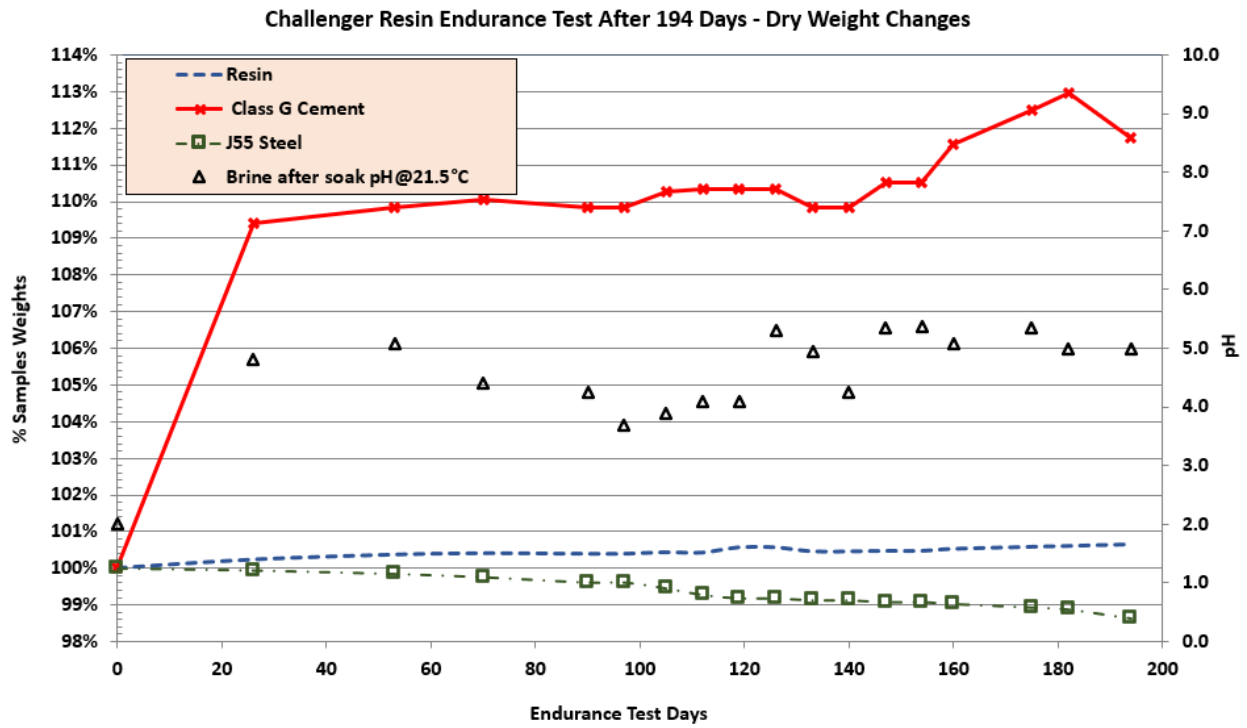


Figure 21: Endurance Test Results As Percent Mass Change After 194 Days



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## 8.0 ACKNOWLEDGEMENTS

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InnoTech is especially grateful for the financial support and oversight provided by PTAC to make this project possible.

Thanks for the outstanding technical capacity of the InnoTech staff who worked on this project which was essential to achieve the desired results.

Thanks also to our career colleagues who have been part of lifelong learning journeys. We appreciate that you have shared your expertise in production operations, reservoir development, drilling, completions, well workover and closure and other operational areas.

**9.0 APPENDIX A - TOXICOLOGY SUMMARY**

Product	Potential Receiving Media	Pathway of Exposure	Affected Receptors	Toxicity	Response	Risk Mitigation Measures
Challenger CC Resin – Component B	Air	Air inhalation	Humans, Wildlife	High	Irritation / Genotoxicity (Cancer) / Fatality	Respiratory protection and wildlife exclusion where in use. Store in well ventilated areas.
	Soil	Direct Contact	Humans, Wildlife	Medium	Irritation / Genotoxicity (Cancer) / Reproductive toxicity, Fatality –Specifically high risk to eyes	Gloves, protective eyewear and clothing on site and wildlife exclusion. Clean up spills immediately.
		Ingestion	Humans, Wildlife	High	Illness / Fatality	Sufficient administrative (labelling) and engineering controls (storage)
	Groundwater	Migration to Surface Water	Aquatic Life	High	Lethality (rainbow trout, guppy, daphnia magna)	Ensure casing integrity and absence of adjacent surface water systems with connectivity with shallow groundwater
Challenger Fusion R3 – Component A	Air	Air inhalation	Humans, Wildlife	Low	Irritation	Respiratory protection and wildlife exclusion where in use. Store in well ventilated areas.
	Soil	Direct Contact	Humans, Wildlife	Medium	Irritation	Gloves and protective clothing on site and wildlife exclusion. Clean up spills immediately
		Ingestion	Humans, Wildlife	Low	Irritation	Sufficient administrative (labelling) and engineering controls (storage)
	Groundwater	Migration to Surface Water	Aquatic Life	Medium	Lethality (Daphnia)	Ensure casing integrity and absence of adjacent surface water systems with connectivity with shallow groundwater

10.0 APPENDIX B - RISK ASSESSMENT – HEAT CHARTS

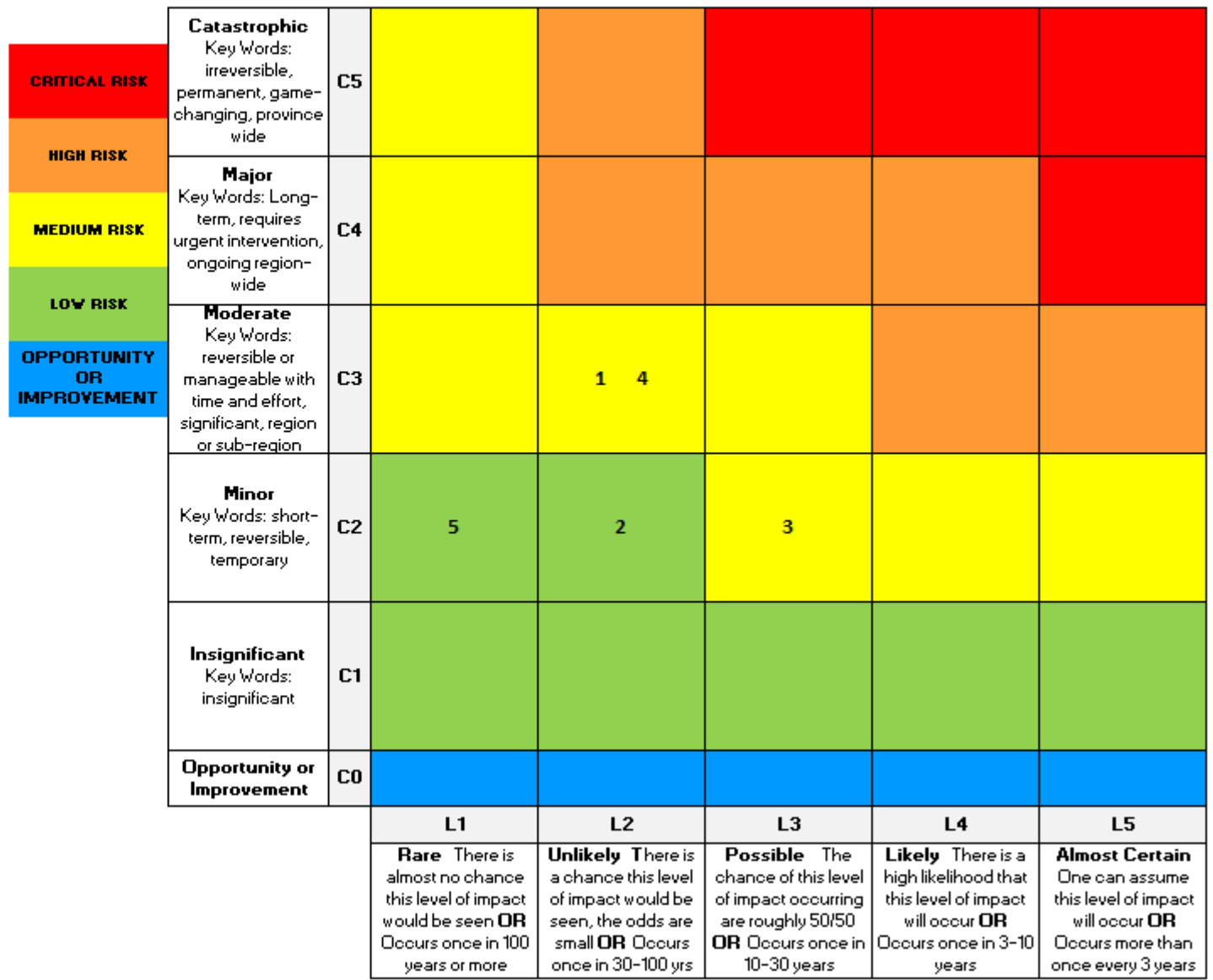
Challenger Resin Risks If a Surface Spill of Components or Liquid Resin Occurs

Prior to setting to a solid, resin is toxic to ingestion or inhalation

Conditions for resin to cause harm at ground level

ITEM #	ITEM DESCRIPTION	POSSIBILITY OCCURRENCE	RISK IMPACT	MAP
1	Resin spilled and does not set to a solid	2	3	L2 C3
2	Spill volume extends outside of a 20 m radius	2	2	L2 C2
3	Field applications not following SOP	3	2	L3 C2
4	Potential for any life to be affected by toxic liquids	2	3	L2 C3
5	Inability to clean up spill or isolate while curing	1	2	L1 C2
6				

UPDATE HEATMAP

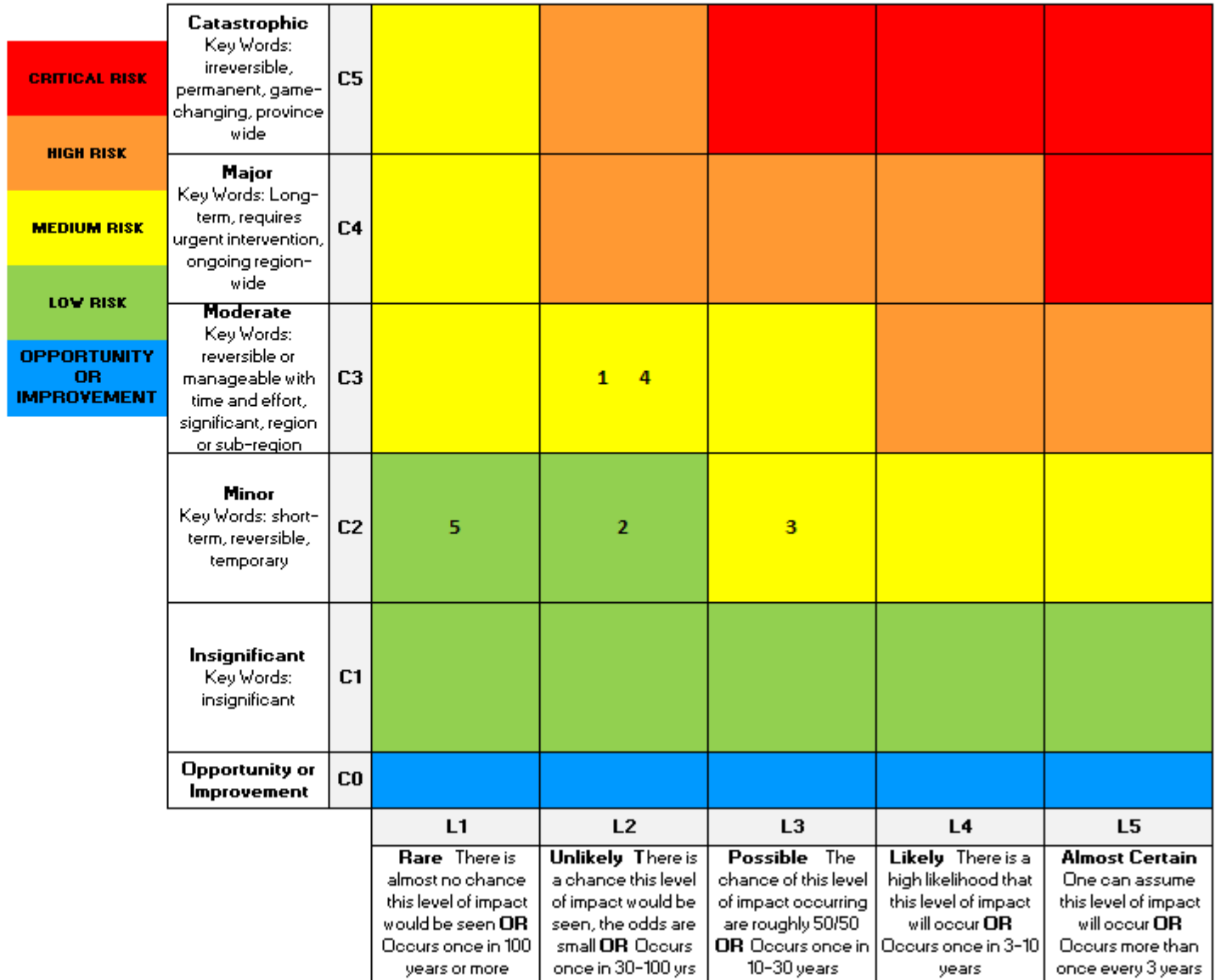




Challenger Resin Risks If a Surface Spill of Components or Liquid Resin Occurs  
 Prior to setting to a solid, resin is toxic to ingestion or inhalation  
 Conditions for resin to cause harm at ground level

UPDATE HEATMAP

ITEM #	ITEM DESCRIPTION	POSSIBLITY OCCURRENCE	RISK IMPACT	MAP
1	Resin spilled and does not set to a solid	2	3	L2 C3
2	Spill volume extends outside of a 20 m radius	2	2	L2 C2
3	Field applications not following SOP	3	2	L3 C2
4	Potential for any life to be affected by toxic liquids	2	3	L2 C3
5	Inability to clean up spill or isolate while curing	1	2	L1 C2
6				

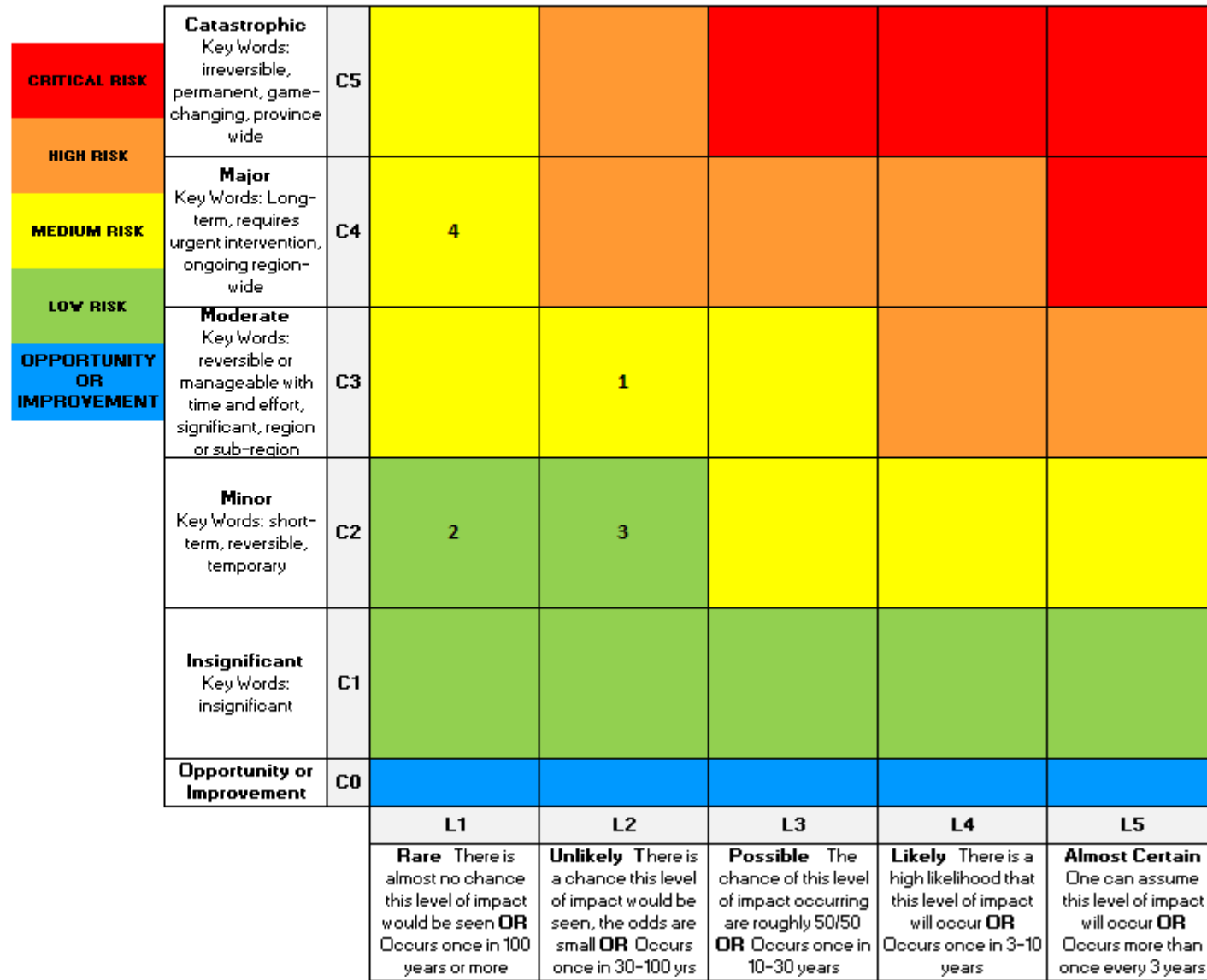


Challenger Resin Risks When Liquid Resin is in Groundwater  
 Prior to setting to a solid, resin is high risk toxicity in ground water

Conditions for a Liquid Resin Plug to Cause Harm in Ground Water

ITEM #	ITEM DESCRIPTION	POSSIBILITY OCCURR	RISK IMPACT	MAP
1	Resin not setting to a solid	2	3	L2 C3
2	Resin to extend outside of a 20 m radius in ground water	1	2	L1 C2
3	Potential for resin moving in ground water	2	2	L2 C2
4	Potential for any life affected by resin in ground water	1	4	L1 C4
5				
6				

UPDATE HEATMAP



# Common Risk Management Framework – Risk Criteria

Version 2.0  
May 2015  
ESRD – DOE –  
PMO – AER – AR

## Risk Assessment

**Risk Assessment:** Is the process of *estimating the likelihood of a specific undesirable event and the severity of the harm or damage caused, together with a professional judgment concerning the significance of the results*

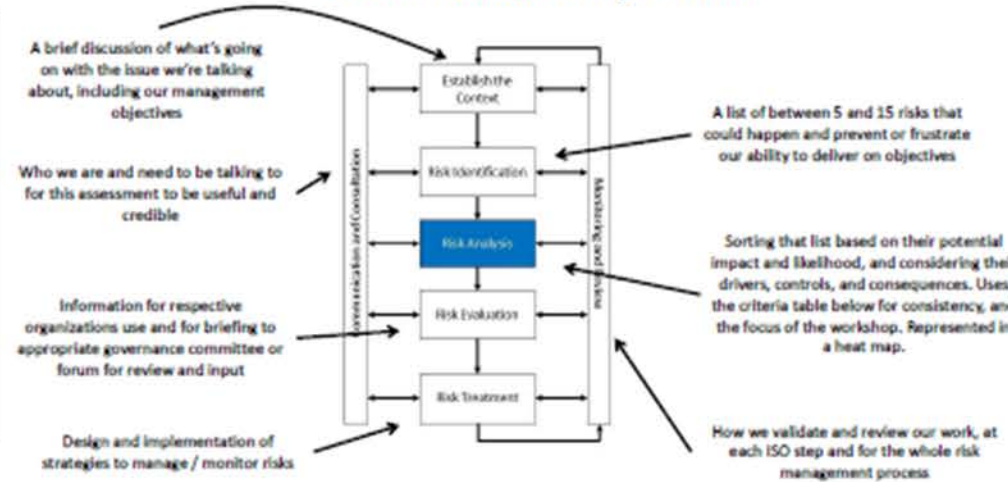
That is... we are using knowledgeable and experienced people like yourself to help us understand what can harm the goals & objectives of the participating organizations; discuss and document details on that harm (its potential impact and probability); and determine how important it is relative to other harms.

We are assessing big, complicated, and abstract concepts at a macro level. Many details are going to be simplified. That is okay. This is going to be messy.

Risk assessments can be thought of as a tool to aid decision-making. The process of carrying out a risk assessment will result in an understanding of the level and significance of organizational risks, and can be used to make better, more effective decisions.

Risk assessments also help to determine whether the level of risk arising from a particular option is acceptable, or whether more needs to be done to control, reduce, or avoid the risk.

## CRMF and the ISO 31000 Risk Management Process



## Process for Using This Table

Our goals are to:

- Develop a shared understanding of risks to objectives; and
- Develop a prioritized list of risks / a coarse screening of risks

The process the facilitator will lead you through includes:

- Reviewing the risk statement (event/condition and consequence)
- Discussing the drivers – current controls – and consequences of risk
- Writing a brief scenario about the risk “happening” to support a shared understanding of what is being assessed, and to make sure we are all talking about the same thing. Best practice guidance suggests focusing on the “most reasonable and probable worst case scenario.”
- Using the risk matrix descriptions below to find the description of impacts on the GOA that best match the scenario outlined by the group.
- Determining the level of impact (by either voting or consensus).
- Determining the likelihood of that level of impact occurring.
- Arriving at a risk level and placing on heat map
- Repeating for the next risk



Environmental Impacts [Air, Land, Water, and Biodiversity]	Economic and Fiscal Impacts [Revenues, Hydrocarbon Development, Investment and Operator Financial Health]	Social Impacts [Disputes and Relationships, Aboriginal Rights, and Community Viability]	Health Impacts [Injuries and Fatalities, Health-Related Limits]	GOA / AER Operational Impacts [Business Continuity, Health and Safety, Assets, Budgets, and Information]	Strategic Impacts [Reputation and Media, Government Objectives, Legal Challenges, and Jurisdictional Issues]	Likelihood
						Impact
<ul style="list-style-type: none"> <li>Irreversible ecological damage at the regional or watershed level</li> <li>Extensive biological and physical disruption of whole ecosystems or communities</li> <li>A species becomes extinct or eliminated from Alberta</li> </ul>	<ul style="list-style-type: none"> <li>Closure of an entire resource sector</li> <li>Loss of existing markets for Alberta's energy resources</li> <li>Permanent or long-term substantial loss of investment in the province</li> <li>Inability for efficient and leading operators to break even on projects</li> <li>Massive reduction in revenues to provincial budgets, necessitating borrowing and game-changing reallocation of resources</li> </ul>	<ul style="list-style-type: none"> <li>Disputes related to hydrocarbons erupt into violent campaigns</li> <li>Extirpation of aboriginal rights to hunt, fish, or trap food</li> <li>Acute or chronic disruption to the viability or fabric of whole communities</li> </ul>	<ul style="list-style-type: none"> <li>Multiple public fatalities</li> <li>Extreme exceedances of limits associated with recognized health-related standards (for example, air quality objectives)</li> </ul>	<ul style="list-style-type: none"> <li>GOA / AER inability to operate for multiple weeks (for example, due to massive loss of staff)</li> <li>Major loss or over-spending of budget leading to mandate-level impacts and reallocation of resources</li> <li>Major loss of GOA and AER assets</li> <li>Multiple staff fatalities</li> <li>Loss or disclosure of significant amounts of highly sensitive data, calling into question GOA / AER credibility and trust</li> </ul>	<ul style="list-style-type: none"> <li>Sustained, long-term loss of stakeholder and public trust</li> <li>Critical government objectives not met (e.g. IRMS or market access)</li> <li>Violation of international and national treaties or agreements</li> <li>Legal challenge reverses key GOA or AER decision</li> <li>Condemnation in the international media</li> <li>Binding international treaties, or federal/provincial legislation and decisions severely constrain the GOA's ability to meet desired outcomes</li> </ul>	<p><b>Catastrophic</b></p> <p>Key Words: Irreversible, permanent, game-changing, province-wide</p> <p>Decision-Making Level: Cabinet, CEO/DM</p>
<ul style="list-style-type: none"> <li>Regionally widespread, adverse environmental impact</li> <li>Manageable negative consequences that are reversible over time but require extensive government intervention and efforts</li> <li>Disruption to communities or species is regionally widespread but of limited severity or reversible</li> <li>Species designated as endangered or threatened</li> </ul>	<ul style="list-style-type: none"> <li>Impacts on a major portion of a resource sector (e.g. in situ extraction)</li> <li>Existing market access is threatened / access to new markets not achieved</li> <li>Substantial loss of investment in the province</li> <li>Inability for the majority of operators to break even on projects</li> <li>Substantial and sustained impact on revenues to the province</li> </ul>	<ul style="list-style-type: none"> <li>Disputes related to hydrocarbon development result in major blockades and campaigns of civil disobedience extremely disruptive to the public</li> <li>Infringement on aboriginal rights to hunt, fish, or trap for food</li> <li>Extreme community social problems</li> <li>Irreparable damage to highly valued structures or items of cultural / historical significance</li> </ul>	<ul style="list-style-type: none"> <li>Single public fatality, multiple serious injuries</li> <li>Ongoing exceedances of limits associated with recognized health related standards</li> </ul>	<ul style="list-style-type: none"> <li>GOA / AER inability to operate for 1 week</li> <li>Disruption of operations requiring permanent or long-term reallocation of resources</li> <li>Over-spending of budget leading to Divisional level impacts</li> <li>Loss of assets valued up to \$5 million</li> <li>Single staff fatality or multiple serious injuries</li> <li>Loss or disclosure of sensitive data or key corporate memory</li> </ul>	<ul style="list-style-type: none"> <li>Major loss of stakeholder and public trust over months</li> <li>Key government objectives threatened and some not met</li> <li>Violation of national agreements</li> <li>Legal challenge reverses major sections of GOA or AER decision</li> <li>Condemnation in the national media</li> <li>Federal or other provincial legislation constrains GOA's ability to meet outcomes.</li> <li>Province required to amend legislation / federal regulatory intervention</li> </ul>	<p><b>Major</b></p> <p>Key Words: Long-term, requires urgent intervention, ongoing, region-wide</p> <p>Decision-Making Level: CEO/DM, EVP/ADM</p>
<ul style="list-style-type: none"> <li>Localized, reversible, or otherwise manageable negative consequences on the environment (air, land, water, and biodiversity)</li> <li>Results in a species being designated of special concern</li> </ul>	<ul style="list-style-type: none"> <li>Impacts on a small section of operators in a resource sector</li> <li>Contributes to challenges with new market access</li> <li>Drop in investment levels in the province</li> <li>Marginal or expensive operators not able to break even on projects</li> <li>Temporary moderate impact on revenues to the province</li> </ul>	<ul style="list-style-type: none"> <li>Disputes related to hydrocarbon development result in isolated blockades and acts of civil disobedience that cause noticeable disruptions to a region</li> <li>Operations that result in frequent or continuous odour and/or noise to such a degree that it threatens the social well-being of a community</li> <li>Impact to social benefits provided by public lands, forests, and wildlife</li> </ul>	<ul style="list-style-type: none"> <li>Multiple serious injuries</li> <li>Infrequent, slight exceedances of limits associated with recognized health related standards</li> </ul>	<ul style="list-style-type: none"> <li>GOA / AER inability to operate lasting less than 1 week</li> <li>Disruption of operations requiring short-term reallocation of resources</li> <li>Over-spending of budget leading to Branch level impacts</li> <li>Loss of assets valued up to \$1 million</li> <li>Multiple serious injuries for staff</li> <li>Loss or disclosure of limited amount of confidential or sensitive data</li> </ul>	<ul style="list-style-type: none"> <li>Loss of trust among stakeholder or public group</li> <li>Key government objectives significantly impacted (delay or major cost increase)</li> <li>Legal challenge to major GOA or AER decision</li> <li>Condemnation in the provincial media</li> <li>Federal or other provincial legislation may constrain GOA's ability to meet desired outcome, or raise questions about GOA management</li> </ul>	<p><b>Moderate</b></p> <p>Key Words: Reversible or manageable with time and effort, significant, region or sub-region</p> <p>Decision-Making Level: EVP/ADM, Executive Directors, Directors</p>
<ul style="list-style-type: none"> <li>Localized (on-site) minimal degradation of the environment</li> <li>Consequences that can be managed using existing processes, but require management effort</li> </ul>	<ul style="list-style-type: none"> <li>Impacts on individual operators</li> <li>Little to no change in market access considerations</li> <li>Noticeable drop in investment levels in the province</li> <li>Least efficient operators may not break even</li> <li>Minor drop in revenues to the province</li> </ul>	<ul style="list-style-type: none"> <li>Disputes related to hydrocarbon development result in isolated acts of civil disobedience that cause minor disruptions to the public</li> <li>Proposed projects or existing activities result in complaints or objections</li> <li>Minor, repairable damage to commonplace structures or cultural values</li> </ul>	<ul style="list-style-type: none"> <li>Minor injuries</li> <li>Approaching limits associated with recognized health-related standards</li> </ul>	<ul style="list-style-type: none"> <li>GOA / AER inability to operate for 1-2 days</li> <li>Disruption of operations requiring modest reallocation of resources for a quarter</li> <li>Over-spending or budget leading to Team level impacts</li> <li>Loss of assets valued up to \$500,000</li> </ul>	<ul style="list-style-type: none"> <li>Trust threatened with stakeholder or public group</li> <li>Achievement of government objectives may be in question</li> </ul>	<p><b>Minor</b></p> <p>Key Words: Short-term, reversible, temporary</p> <p>Decision-Making Level: Directors, Managers</p>
<ul style="list-style-type: none"> <li>Insignificant impact to the environment</li> <li>No measureable residual effects</li> <li>No action other than baseline oversight required</li> </ul>	<ul style="list-style-type: none"> <li>Temporary or local events that are easily managed with existing processes</li> </ul>	<ul style="list-style-type: none"> <li>No measureable residual effects</li> <li>No action other than baseline oversight required</li> <li>Isolated concerns</li> </ul>	<ul style="list-style-type: none"> <li>Insignificant impact to human health</li> </ul>	<ul style="list-style-type: none"> <li>Inability to operate for a number of hours (&lt;24 hrs.)</li> <li>All other impacts easily managed at the team or individual level</li> </ul>	<ul style="list-style-type: none"> <li>Insignificant impact on strategic objectives</li> </ul>	<p><b>Insignificant</b></p> <p>Key Word: Insignificant</p> <p>Decision-Making Level: Managers, Staff</p>
<ul style="list-style-type: none"> <li>Improvement in environmental outcomes</li> </ul>	<ul style="list-style-type: none"> <li>Improvement in economic outcomes</li> </ul>	<ul style="list-style-type: none"> <li>Improvement in social outcomes</li> </ul>	<ul style="list-style-type: none"> <li>Improvement in health outcomes</li> </ul>	<ul style="list-style-type: none"> <li>Increased likelihood of achieving operational objectives</li> </ul>	<ul style="list-style-type: none"> <li>Increased likelihood of achieving strategic objectives</li> </ul>	<p><b>Opportunity or Improvement</b></p>

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## 11.0 APPENDIX C - STANDARD OPERATING PROCEDURE

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### **Challenger Technical Services Ltd. – Standard Operating Procedure for Resin Applications**

For more Information call 780 724 4117 or 750 573 0888 or 587 225 5953.

Oil and gas service companies have safety policies and standard operating procedures (SOPs) to conduct field work in a safe and efficient manner for their clients and to ensure that regulatory requirements are met. Enclosed are SOP recommendations for Challenger which are specific to the resin which was assessed and tested by InnoTech.

#### ***General and Safety***

The SOP should contain emergency response and contact information and the location coordinates by unique well identifier (UWI) and by emergency responder coordinates.

SDS information must be retained on all locations for all products and materials that are on location, in transport and in storage.

All personnel must wear approved industry standard PPE (i.e., eye protection, coveralls, safety boots, gloves, approved respirator mask), when handling or mixing materials / products.

Conduct onsite safety meetings and ensure personnel are following all local regulations and the Prime Contractors (typically the oil and gas company) policies for the specific work site. Review SDS material on site and ensure a sign off sheet for on-site personnel is used to confirm that the proper mixing and placement procedures are followed.

Ensure that mitigation materials and equipment are on hand to safely contain and clean up a spill should a surface spill occur. Ensure that safe operational procedures are understood in the event of a spill.

If the resin and associated material is used as a casing abandonment plug, prior to mixing the resin confirm that casing and bridge plug were successfully pressure tested and if possible, include the pressure test with the field reports.

Ensure that the equipment required for field mixing operations is intrinsically safe for on-site use or that the mixing is conducted far enough away from any source of potential leaking natural gas or flammable materials to meet all regulations.

Examine the containers with materials for the planned operation and confirm that the UWI and field program are correct for the planned operation. Prepackaged materials may be measured prior to transport for a specific field application.

Mix the contents according to the Challenger mixing procedures and retain resin slurry samples as required to confirm setting time and for potential audit purposes. Place products in wellbore as per the intervention program. During product placement ensure that adequate mitigation procedures are taken to optimize contact of the resin with the wellbore components and contact surfaces. This may include displacement of wellbore fluids away from the contact surfaces using designed mutual solvents or surfactants such as soapy water. Record details of actual operations.

Follow clean up, transportation and disposal procedures in accordance with Challenger’s requirements, the Prime Contractor’s requirements, and all local regulations.

***Storage and Transportation***

Identify the product shop storage and transportation temperatures limitations for all products. Keep products sealed in drums, totes or pails during transport and storage. Ensure all containers are properly labeled with the contents.

Identify materials that must be stored in a ventilated area and ensure ventilation is maintained. Identify if any materials cannot be stored or transported in direct sunlight and ensure the guideline is followed.

Ensure correct Transport of Dangerous Goods placard are on all containers. When transporting to a job site ensure containers are secured in an appropriate compartment and follow guidelines for controlled temperature, ventilation, humidity, wetness, sunlight, and security.

***Mixing Procedure***

- Follow the Challenger mixing procedure for resin considering the following:
- Use PPE as required when handling components.
- Use a clean container that will hold the required volumes and allow room for mixing.
- Weight out / measure volumes of components / ingredients in the order they will be mixed and placed in the mixing container.
- mmix with the method and time recommended.

***Quality Control & Quality Assurance (QA/QC)***

It is a good practice to provide verification in the SOP that a QA/QC procedure was followed and the date(s) that the QA/QC evaluation was conducted. Some suggestions are listed below:

- Upon delivery from the manufacturer each new batch of chemicals will be sample tested to confirm design criteria.
- If multiple manufacturers are supplying the equivalent base chemicals or products, then each batch should be sample tested to confirm that the design criteria and specifications are met.
- Chemical and product containers should readily identify the date that the chemical or product was manufactured.
- Retain cured samples as required for regulations, audits, best practices, and customer requirements.

***Sign off Sheet Validating Data For Resin Components, Field Mixing and Job Procedures***

A field sheet signed by Challenger and the prime contractor or oil and gas company after a wellbore intervention is an important link for the regulator and all parties to track and retain records for auditing the deployment of the resin. The following items are recommended for inclusion into the field sign off document.

Customer Name - \_\_\_\_\_

Prime Contractor - \_\_\_\_\_



Well Name - \_\_\_\_\_

Location - \_\_\_\_\_

Location UWI - \_\_\_\_\_

AFE - \_\_\_\_\_

Date of Service - \_\_\_\_\_

Include the 'lot numbers' of the chemicals or something similar \_\_\_\_\_

\_\_\_\_\_

Resin Components Used in Field

<i>Product Name</i>	<i>Liquid or Powder</i>	<i>Weight/Volume Mixed</i>
Component 1		
Component 2		
Component 3		

Identify any specific regulatory request/limitations:

\_\_\_\_\_

Field Notes

\_\_\_\_\_

Record weather conditions and any operational limits:

\_\_\_\_\_

Wellbore Diagram - Before Treatment (optional):

Wellbore Diagram - After Treatment (optional):

Field Sign Off Sheet for the Prime Contractor and Challenger

*Prime Contractor and Challenger to retain signed copies for audit purposes*

Name of Person Signing	Prime Contractor / Challenger	Contact Info	Signatures