Location: Grosvenor Mine

Title: Polymeric Chemical Evaluation – DSI vs. Minova

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Scope

This report is intended to evaluate the suitability of the proposed switch of polymeric chemical supplier from Minova to DSI. The current chemicals in routine use at Grosvenor Mine from Minova are compared against the equivalent products available from DSI.

The Purpose of Strata Consolidation Products

The main purpose of strata binders is to consolidate and confine the material that is already in a fractured state. Grosvenor uses these products predominantly in the longwall face which is usually in a stress relived state and hence would not require significantly high compressive strength properties Galvin (2016). The most critical aspect in comparing strata consolidation products is the time to react and the ability to bind to the fractured strata. Furthermore, the foam factor of the strata consolidation product is critical in assessing the suitability.

Material Specification

The specification of material properties of polymeric chemicals is not as straightforward as that for support elements such as rebar, cable bolts or grouts. Each type of chemical has different properties that can make them more suitable for certain applications. The basic physical properties for polymeric chemicals include the following;

- Compressive Strength (MPa)
- Adhesive Strength (MPa)
- Tensile Strength (MPa)
- Flexural Strength (MPa)
- Viscosity (MPas)
- Foam factor (ratio of starting volume to final volume)

A summary for all properties available from the product data sheets for both companies is shown in the table below. Broadly there are two types of chemicals; strata binders and void fillers. The strata binders include the polyurethane (PUR) and urea silicate (URS) resins and void fillers phenolic foams (PF). Strata binders find application in many areas of the mine including sealing water, binding

broken strata and encapsulating support elements the void fillers almost find sole application on the longwall filling cavities.

For chemicals used to fill cavities it is the “foam factor” that is the property of most interest. Foam factor is measured as the volume expansion from the input chemicals to the final product, either by weight or by volume. Some suppliers also quote a compressive strength i.e. 0.2MPa for Rocsil from Wilsons, however this is not always specified. Quoted foam factors are often not in agreement with the volume of product used in practice and an ongoing QA/QC process is required to track usage. Moreover, each product will perform differently at different foam factors also and this needs to be understood by both the supplier and mine operator.

Table 1 – Polymeric Chemical Material Properties Summary

Supplier	Product Name	Generic Name	Foam Factor	Comp. Strength (MPa)	Adhesive Strength (MPa)	Tensile Strength (MPa)	Flexural Strength (MPa)	Punched Shear (MPa)
DSI	Strata Bond HA	PUR	1-5	70	>3	30	40	-
Minova	Bevedol	PUR	1.7-5	80/20	>3	45	90	-
DSI	Mineral Bolt	USR - cables	1	65	-	-	21	20
Minova	Carbothix	USR - cables	1	70				25
DSI	Mineral Bond LV	USR - injection	1	40	5.5	-	18	25
Minova	Geoflex	USR - injection	1		5.8			
DSI	Fixorapid	APR	1					
Minova	Carbo Mine	APR	1		7.3			
DSI	Mine Fill	Phenolic Foam	40-55	0.035	N/A			
Minova	Carbo Fill	Phenolic Foam	32-38	N/A	N/A			

Note: PUR – Poly Urethane Resin, USR – Urea Silicate Resin, APR – Alkaline Phenolic Resin

A surface demonstration of all the strata consolidation products were completed in Mackay at the DSI warehouse in Mackay. The following videos demonstrate the behavior of DSI strata consolidation products.

- DSI Mine Fill
- DSI Mineral Bolt Trial
- DSI Mineral

Chemical Specification

The specification of chemical properties of polymeric chemicals is a complex task and more suitable for analysis by an industrial chemist or occupational health specialist. Each product has a hazardous substance or substances that needs to be controlled during its use. The chemical approval process at each mine is used to manage this process. Based on the desktop study there appears to be no major difference between suppliers with chemicals such as isocyanates, phenols and formaldehyde

all present. The volumes of each may vary depending on the ratios pumped at and the environment they are working in.

Hazardous Substances

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Table 2 – Polymeric Chemical Hazardous Substances Summary

Supplier	Product Name	Component	Ingredient	Exposure Standard (TWA)	Exposure Standard (STEL)
DSI	Strata Bond HA	Part B	Isocyanates, all (as-NCO)	0.02 mg/m3	0.07 mg/m3
Minova	Bevedol	Part B	Isocyanates, all (as-NCO)	0.02 mg/m3	0.07 mg/m3
DSI	Mineral Bolt	Part A	Diethylene Triamine	1 ppm / 4.2 mg/m3	NS
		Part B	Isocyanates, all (as-NCO)	0.02 mg/m3	0.07 mg/m3
Minova	Carbothix	Part B			
DSI	Mineral Bond LV	Part A	Ethylene glycol (particulate)	10 mg/m3	NS
		Part A	Ethylene glycol (vapour)	20 ppm / 52 mg/m3	40 ppm / 104 mg/m3
		Part B	Isocyanates, all (as-NCO)	0.02 mg/m3	0.07 mg/m3
Minova	Geoflex	Part B	Isocyanates, all (as-NCO)	0.02 mg/m3	0.07 mg/m3
DSI	Fixorapid				
Minova	Carbo Mine	Part A	Formaldehyde	1ppm / 1.2 mg/m3	2 ppm / 2.5 mg/m3
		Part A	Phenol	1 ppm / 4 mg/m3	NS
		Part A	Potassium Hydroxide	2 mg/m3	NS
DSI	Mine Fill LVII				
Minova	Carbo Fill	Part A	Formaldehyde	1ppm / 1.2 mg/m3	2 ppm / 2.5 mg/m3
		Part A	Phenol	1 ppm / 4 mg/m3	
		Part B	Phosphoric Acid	1 mg/m3	3 mg/m3
		Part B	Sulfuric Acid	1 mg/m3	3 mg/m3
DSI	Mine Flush	Cleaning agent	Sodium Carbonate	10 mg/m3 (total dust)	NS
Minova	Phenet	Cleaning agent	Sodium Carbonate	NS	NS

Properties Evaluation

Although the physical and chemical properties listed above are important and are specified for all products Galvin (2016) lists several positive attributes of PUR that are key to its success as follows;

- Low viscosity allowing migration into cracks
- Increase in volume after pumping (foaming)
- Variable setting time from seconds to hours

- Flexibility, ductility and bonding properties
- Ability to absorb water (hydrophilic) and hence suitable for sealing inflows

Logically these can be applied to other strata binding materials such as grouts and urea silicate resins where appropriate.

Summary

This report has evaluated the technical specification of Poly Urethane Resin, Urea Silicate Resin, Alkaline Phenolic Resin between Minova and DSI. Based on this desktop study there is no significance difference between the Minova and DSI products. The significant advantage from an operational aspect is that DSI have the capability to pump all strata consolidation from the surface which will limit underground interactions.

Recommendation

An operational review will be completed after the initial utilisation of DSI products underground to determine if any additional controls are required to make the process more effective at Grosvenor. Ongoing QA/QC will be completed to provide routine checks to determine effectiveness of strata consolidation products on an ongoing basis.

Date	Approver	Role	Signature
12/7/2019	Rav Goonawardene	Geotechnical Superintendent (RPEQ)	
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