Kevlar Whip-Restraints

Anglo American Metallurgical Coal Moranbah North Management

The Problem or Initiative:

The Anglo Operational standard and MDG41 (MDG41 is a document which was created in response to an increasing number of incidents involving high-pressure fluid injection injuries on mine sites. In response to this, the NSW Department of Primary Industries established a joint committee with involvement from the Mining Industry, Equipment Manufacturers, Repairers, and Suppliers of Fluid Power components in order to formulate a 'best-practice' document), requires all high pressure hoses to be restrained in case of hose failure or accidental uncoupling which could cause the hose assembly to whip violently due to sudden release of energy.

This sudden release of energy could make the whipping hose lethal and create a dangerous situation. In such situation, whip-restraints (also known as whip checks, whip socks, or hose restraints) ensure safety from injury and property damage. Current practise within the mining industry utilises metal whip-restraints. These whip-restraints are safety cables made of corrosion resistant, high strength steel which on installation diverts strain on the coupling to the whip-restraints. Whip-restraints are used throughout the mining industries including: longwall roof support hoses, air hoses, water blasting, drilling, steam, concrete, sandblasting or other high pressure applications.

The hose restraint principle has been widely adopted for a number of years, as a static in use system it performed its function without fail. The drawback with the system was when the following occurred:

- When hoses needed to be replaced, the whip-restraint needed to be removed from the failed hose and routed onto the new hose, this in some cases did not occur resulting in a substandard operational installation.
- When the hoses were of a different configuration, i.e. had spiral wrap fitted making it extremely cumbersome to re-fit a whip-restraint.
- When the whip-restraint became exposed to unusually high corrosive environments which tended to compromise the whip-restraint's integrity.
- Typically the strands of the metal whip-restraints begin to fail and can result in injury to personnel. Injuries can vary from cuts/scratches to a deep cut on the body requiring stitches which could then lead to possible tetanus illness and bacterial infection of the wound; to broken bones of the limb to death.
- Increased manual handling in getting the whip-restraint to fit over the hose properly.

At Moranbah North, the following hoses are restrained:

- On the powered roof supports
  - DN20 Solenoid feed
  - DN25 Positive-set pressure feed
  - DN50 System pressure feed
- All Mono-rail hoses

The Solution:

Owing to the afore mentioned background of the steel type whip-restraints and the noted drawbacks, a conscious decision was made to actively pursue an alternative application for the operation.

Bullivants were approached to lend expertise and assist with finding an alternative solution to the metal whip-restraints currently in use at Moranbah North Mine. Following the Change Management and risk assessment process, a “Kevlar whip-restraint” trial was undertaken. The trail included the use of the whip-restraints on powered roof support DN20 Solenoid feed, DN25 Positive-set pressure feed and DN50 System pressure feed hoses. The primary intention of the trial was to eliminate personal injury, corrosion and increased manual handling.

A Kevlar whip-restraint is a poly coated high tensile rope comprised of a ‘Parafil’; which consist of a closely packed core of high strength synthetic fibres lying parallel to each other. The Parafil is encased in tough and durable polymeric sheath. Each Kevlar whip-restraint start from approximately $250.00, and increase in value depending on width and length of the whip-restraint required. Various types of the Kevlar whip-restraints are available including, single eyed and double eyed whip-restraints; 2ply, 3ply or 4ply whip-restraints.

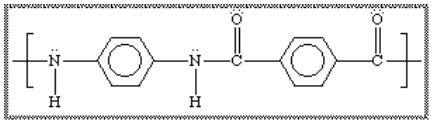
A double eyed whip-restraint.

Other features of the Kevlar include:

- UV resistant
- Highly resistant to water
- High tensile strength at low weight
- High modulus (structural rigidity)
- High chemical resistance
- High toughness (work-to-break)
- High cut resistance
- Low elongation to break
- Low electrical conductivity
- Low thermal shrinkage

- Excellent dimensional stability

The Kevlar (chemical name for Kevlar is poly(*p*-phenyleneterephtalamide)) is itself a carbon based aramid. An aramid is a manufactured fibre related in chemical composition to the nylon family, yet its properties vary greatly from nylon. Aramids are prepared by condensation of a diamine and teraphthalic acid, a carboxylic acid that contains a hexagonal benzene ring in its molecules. The aramid ring gives Kevlar thermal stability, while the para structure gives it high strength and modulus.



Chemical structure of Kevlar.

Benefits/Effects:

Kevlar whip-restraints are light weight and easier to manevour on and off the hoses; thus eliminating the extra manual handling from the metal whip-restraints. They do not cause abrasions to personnel whilst installing the Kevlar whip-restraint onto the hose due to the polymeric coating. The Kevlar whip-restraints do not corrode and are flame retardant; the fibres do not melt but decompose at around 460^{o}C. When the Kevlar whip-restraints break, the polymeric sheath ruptures, exposing the Parafil rope inside. If personnel brush against the exposed Parafil rope, they do not incur an injury as the Parafil rope is not sharp unlike the metal whip-restraints, which results in an injury to the person.

NATA testing was conducted prior and post trial; table 1 illustrates the results. The trail was conducted over a period of 6 months; from these results it is evident that the Kevlar whip-restraints do not loss their integrity during their time in use. No Kevlar whip-restraints were replaced during the trial period.

Table 1: Prior to trail and post trail breaking results of Kevlar whip-restraints

Hose / Ply	Prior to trial Break Test (Kg)	Post trial Break Test (Kg)
1 inch / 2 ply	3307	4413
2 inch / 3 ply	5428	5737

Transferability:

Kevlar is currently used in making bulletproof vests, belts for radial tires, cables, reinforced composites for aircraft panels and boat hulls, flame-resistant garments, sports equipment such as golf club shafts and lightweight bicycles, and in asbestos replacement in clutches and brakes.

Parafil is currently used in antennae and electrical industries are insulating guys, catenaries and support systems; providing excellent insulating properties and resistance to UV degradation to ensure a long and essentially maintenance free life. Parafil is now used in urban transport system in overhead conductors for supporting tram and trolley buses. Parafil is also used in marine application for buoy moorings, ship and yacht rigging, guard rails and tow ropes. There are potentials for a ‘lace up’ style whip-restraint for longwall chock hoses.

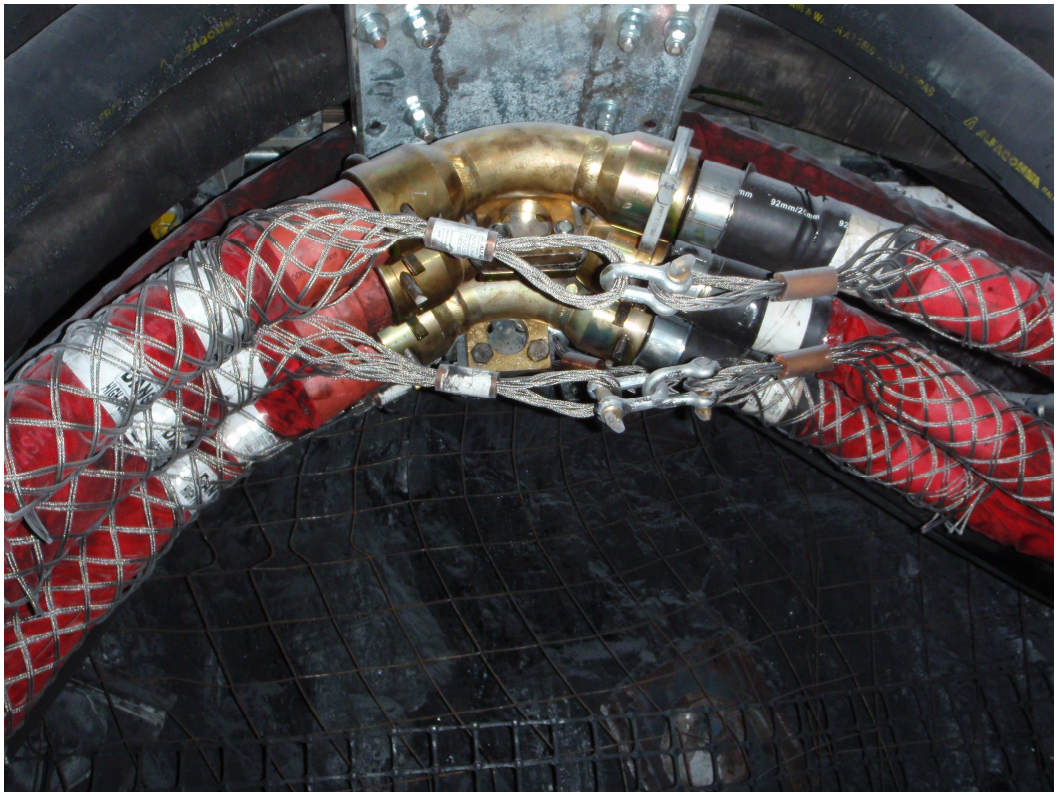
Moranbah North is looking at fully integrating the Kevlar whips onto all of the longwall chock hoses.

A metal whip-restraint.

Entire strand on the metal whip-restraint failing, which can cause injury to personnel.

Strand of the metal whip-restraints broken which can cause injury to personnel

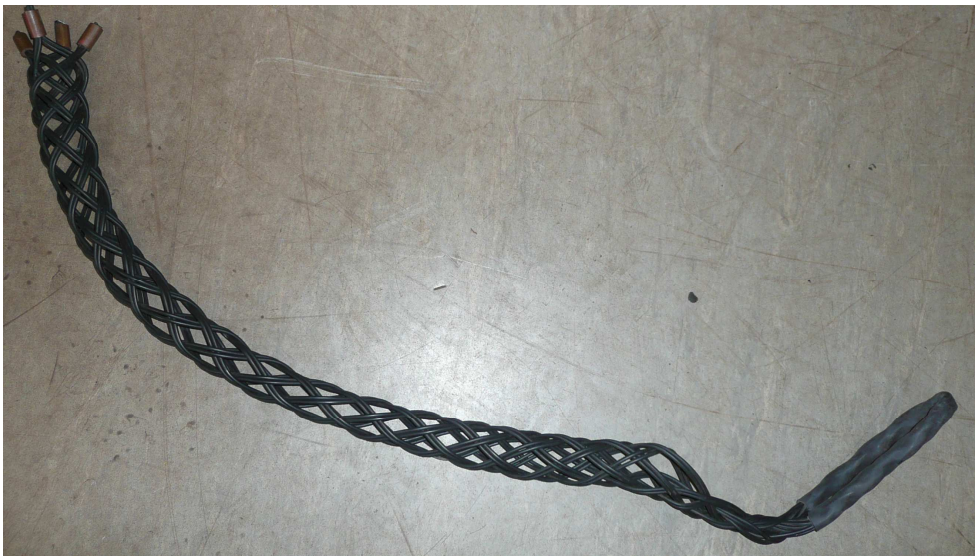
Individual wire strands broken on metal whip-restraints - can cause injury to personnel



Metal whip-restraints in use on the monorail of the longwall

Whip-restraints located on the longwall chock hoses.

Single eye 2 ply Kevlar whip-restraint on a 1 inch hose



Single eye Kevlar whip-restraint

Kevlar whip-restraint at breaking point – note the fibres are easily seen when the Kevlar whip-restraint is broken, nor do the fibres result in injury to personnel