General Approval application example:

Mining/Welding

IMPORTANT NOTE

This is a fictitious example of a General Approval application. It is intended as a guide only to provide an indication of the level and type of detail required in the RDTI General Approval form.

1. PROJECT DESCRIPTION

1.1. Project Identifier

R&D to enhance the life of gyratory mineral crusher mantles used in the reduction of metalliferous ore in mining. The goal is to increase the life of the mantle by a factor of three.

1.2. Project Objective

Crusher mantles have a useful life predicated on the hours of use, the medium being crushed and the material it is cast from.

Each time mantles are replaced due to wear, the mine operation needs to shut down for several hours which can easily cost upwards of $100,000. The lost productivity cost is in addition to the cost of the mantle itself.

This project sought to enhance the life of the mantle (which in this case is cast from manganese steel) through coating with a harder wearing metal that would prolong its life and thereby reduce costs that come from having to shut down the mine for mantle changes.

2. PROJECT CORE ACTIVITIES

2.1. Core activity

Determination by the optimal coating layers of weld metal to reduce spalling and enhance crusher mantle life.

2.1.1. DESCRIBE YOUR CORE ACTIVITY

Our solution involved two stages;

1. The development and laboratory trial of various combinations of hard surfacing materials on the manganese steel substrate. A range of more malleable intermediate layers of more ductile materials were used to reduce the likelihood of the hard surfacing spalling off the substrate when under the stresses found in crusher operations. Previous attempts at hard surfacing had failed due to spalling of the weld metal with attendant damage to the substrate. Material candidates were identified for in-situ testing.
2. The development of a coating method to coat the mantles with the layers of weld metal, followed by an operational trial.

2.1.2. DESCRIBE THE SCIENTIFIC OR TECHNOLOGICAL UNCERTAINTY THAT YOUR CORE ACTIVITY HAD A MATERIAL PURPOSE OF RESOLVING

There was an existing common issue with hard surfacing applied to manganese steels used in rotational gyratory equipment where an aggressive cyclic load existed. The issue contained technological uncertainty in how to achieve resistance to spalling in that environment.

There was considerable information available on welding materials and their application. Hard surfacing had also been successfully applied to a range of metal substrates, including manganese steels. The closest example to our application was the use of hard surfacing on crusher rolls, which are used in reducing the size of gravel. However, there was little information on solving the spalling issue where there are extreme point, rotational and gyratory cyclic loads, and none in relation to crusher mantles.

Our experienced team of welding engineers were unable to say with certainty that the issue could be solved, but they hypothesized that a ductile intermediate layer may mitigate the spalling experienced with direct application of the hard surfacing.

2.1.3. DESCRIBE THE SYSTEMATIC APPROACH YOU TOOK CONDUCTING THE CORE ACTIVITY

The components of the research activity are detailed in a project plan (copy attached) and include written methodologies for preparing the coupon test pieces, conducting the testing regime, and documenting and evaluating the test results. The steps in the overall project are mapped out in a Gantt chart that is subject to review at scheduled project meetings.

Overview of systematic approach:

- →Selection of candidate weld metals based on literature review and consultation with experts in the field.
- →Pairing of candidate weld metals and preparation of test coupons as specified in the following standards:
  - →Charpy Notch Impact Test – ISO148 Izod
  - →Impact Test – ISO/R 84:1959 Ductility
  - →Test – ASTM E8/E8M
  - →Torsional Fatigue Test – In house design to establish the difference between material pairs in cyclic load conditions

The candidate pairs were assessed using a range of methodologies to determine the parameters of failure and were rated against coupons, made from the base metal manganese steel and existing hard surfacing material, as a control.

The candidate pair that performed the best was then selected for full-scale trial under variable cyclic impact load conditions. A number of trials of deposition methods were conducted and the most effective at meeting a range of technical requirements and constraints was selected.

A machine was developed to control the weld deposition and ensure repeatability should a second candidate material require testing. A test mantle was then produced and installed for a field trial. Measurements were taken and the condition of the trial mantle was assessed according to a schedule.

2.1.4. DESCRIBE HOW YOUR CORE ACTIVITY INTENDS TO CREATE EITHER NEW KNOWLEDGE OR NEW OR IMPROVED PROCESSES, SERVICES OR GOODS

The new knowledge built on our understanding of how two different metals bond together on a base metal and how they perform under random cyclic loading. Solving this problem contributed significantly to achieving longer wearing crusher mantles, resulting in reduced crusher downtime, higher throughput of feedstock and reduced costs.

3. PROJECT SUPPORTING ACTIVITIES

3. Supporting activity (1)

Develop a shear, impact and fatigue test rig for coupon samples.

3.1. DESCRIBE YOUR SUPPORTING ACTIVITY

We needed to develop test rigs and methods that would allow us to establish the failure mode and point for each test coupon. This was not a standard test as it sought to replicate in micro the point load experienced in a mantle, so that prospective candidate materials could be identified for full-size testing in an operational setting.

3.2. DESCRIBE HOW THIS SATISFIES THE SUPPORTING ACTIVITY DEFINITION

Developing a shear, impact and fatigue test rig for coupon samples was an integral activity as it enabled us to complete the steps indicated in the systematic approach, and not rely solely on theory, guesswork, and trial and error.

3. Supporting activity (2)

Development of the weld metal deposition system.

3.1. DESCRIBE YOUR SUPPORTING ACTIVITY

Developing the weld metal deposition system involved an automated deposition process and methodology that could cope with a substrate of varying depth of profile and the application of known and bespoke components.

The welding process involved the application of a range of technologies in concert to achieve an outcome. This included the use of tracked rack and pinion travellers adopted from welding straight seams in shipbuilding. These were supported to work on a sideways incline, involving two angle-adjustable arms positioned on each side of the mantle. The tracks used crawler assemblies to support the flux-cored wire MIG drive units powered by stepper motors to move between layers of weld.

Further, stepper motors driving the geared heads, positioned the MIG nozzles at the correct distance from the mantle in order to follow the curve of the substrate. The mantle weighed several tons and was fixed to a rotating base powered by a variable speed DC drive.

Each revolution of the base triggered a microswitch that signals a timer on the stepper motors which would activate the crawler assemblies that were positioned on opposite sides of the mantle. The flux-cored wire drums were positioned on freely rotating tables that ensured a ready-feed to the MIG heads. The power sources were two solid-state 100% duty cycle welders that could operate continuously for several days.

The welding process was developed to meet the challenges of depositing in a highly controlled and reproducible way, with many tons of weld metal on a surface of variable vertical inclination and at varying diameters.

3.2. DESCRIBE HOW THIS SATISFIES THE SUPPORTING ACTIVITY DEFINITION

The weld metal deposition process was critical to the prospective success of the project. It ensured repeatable and precisely controlled deposition in order to optimise the performance of the weld metal layers.

3. Supporting activity (3)

Pre-assessment, documentation and project management.

3.1. DESCRIBE YOUR SUPPORTING ACTIVITY

Pre-assessment, documentation and project management included a literature search, FTO review, project and experimental planning, management and documentation.

3.2. DESCRIBE HOW THIS SATISFIES THE SUPPORTING ACTIVITY DEFINITION

This activity ensured that the current state of the art is known and that the project was appropriately planned, managed and governed with methodologies and results documented.

3. Supporting activity (4)

Preparation, installation, monitoring and removal of test mantle.

3.1. DESCRIBE YOUR SUPPORTING ACTIVITY

This involved preparation of the test mantle coated with the bi-metal surfacing, and installing it into the crusher, the activities for measuring wear and monitoring performance, followed by the removal, examination and disposition of the test mantle.

3.2. DESCRIBE HOW THIS SATISFIES THE SUPPORTING ACTIVITY DEFINITION

This was the testing and monitoring stage that determined if the weld metal coatings and application methodology performed towards achieving the goal of reduced mantle wear.