FRAMEWORK FOR THE EFFECTIVE REPAIR MANAGEMENT OF CRITICAL ASSETS

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All good repair plans require a work strategy based on an informed and qualified assessment of the repair requirements. To better understand the condition of the asset, there are some upfront questions that can be asked to form the decisions to be made for recovery of the machine.

The questions include:

- What is the motivation for the repair?
- What components have failed?
- How are these components adjudicated?
- How have these components compromised reliable operation?
- What contributors to the failure need to be effectively recovered to prevent a recurrence of the failure?
- What risks are introduced by effecting remedial work?
- Is removal for remedial work the correct and best way to recover reliability,
- Is there a reliable spare?
- What consequential impacts of removal and replacement with the spare are presented?
- Is reliability compromised sufficiently to warrant the effort and expense?
- Can a repair be effected with the motor in position?
- Are the correct skill sets available to effect this repair?

An initial concern that influences the decision on how to repair the failed motor is the lost production opportunity and down time cost that will business will incur while the repairs are underway. When decisions are made using speed of repair as the main decision criterion, the urgency to replace the motor can compromise the development of good repair plans. Creating a repair plan based on getting the asset back online in the shortest time physically possible is not always the best strategy.

Fig 1 to *Fig 4* show the consequences and premature failure of machines that returned to service after ‘quick’ recovery overhaul, rather than taking the time to properly asses their machine and create a repair management strategy that best suited the situation.

Figure 1: *Severe slipring flash over*

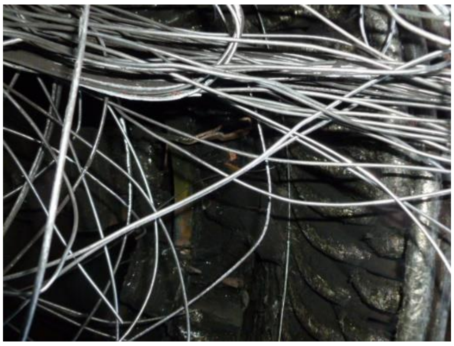

Figure 2: *Rotor banding failure*

Figure 3: *Fault at stator winding series connection*

Figure 4: *Consequence of re-switching on to the fault identified above*

Once the extent of the failure has been understood and the decision is made to remove the machine for repair, there are still some further detail which require consideration before choosing a repair strategy.

- The repair scope requires definition,
  - If the requirement is for an overhaul of the motor, the owner needs to identify the specific aspects for overhaul.
  - If the repair requires significant intrusive re-work, a root cause analysis assessment should be conducted to identify contributors to the fault. This ensures that the recovery can include removing or mitigating the offending factors to prevent re-occurrence of the failure.
  - Was there an external influence that caused the motor failure? When external influences are found, it is important to investigate if they can be minimised or eliminated to prevent future failures.
- Consider the best option to complete the repair
- How will repair be qualified?
  - Identify objective measures defined by industry standards
  - Consider the application of the repair

The considerations described above give the information required to facilitate specifying the required remedial work. The next step is to compile a specification with detail of the repair required and identify vendors that are competent and capable of doing the necessary work. When sending an inquiry to the qualified vendors for quotes on the repairs, you should request a repair timeline and an inspection, along with a test plan for the repair from the vendor in accordance with the specification.

When adjudicating the proposals, it's important to consider the urgency and integrity that is required for the return of the machine to site. Although a proposal may see the machine being restored to working order faster than other proposals, it may be only a short term solution that would lead to failures sooner than could be prevented. Once a quality assurance strategy has been implemented, the contract is awarded to the best repair management plan.

Once the repair contract has been placed, the requirement is to monitor progress against the supplied Gantt chart and inspection and test plan. An example of this can be seen in Figure 6. Control documents are used to identify when strategic quality assurance inspections can be conducted.

Stage	Document	Date
Specifications	Winding Installation Methodology	30 Mar 2016
	Repair Specification	05 Apr 2016
	QA Plan	05 Apr 2016
Opening	ACH Recovery Plan	08 Mar 2016
	Gantt Chart	08 Mar 2016
Progress	Meeting Minutes	23 Mar 2016
	Meeting Minutes	04 Apr 2016
	MM Inspection Report	21 Apr 2016
	Core Loss Test Certificate	22 Apr 2016
	MM Inspection Report	26 Apr 2016
	Vendor Progress Report	05 May 2016
	Update Gantt Chart	05 May 2016
	DDF Test Report - Coil Manufacturer	05 May 2016
	Sample Type Test - Coil Manufacturer	05 May 2016
	HV Test Report - Coil Manufacturer	05 May 2016
	Meeting Minutes	09 May 2016
	Vendor Weekly Report	13 May 2016
	Vendor Weekly Report	19 May 2016
	Meeting Minutes	20 May 2016
	RTD Placement Diagram	20 May 2016
	Vendor Weekly Report	26 May 2016
	ACH Coil Test Record Sheet	26 May 2016
	Vendor Weekly Report	03 Jun 2016
	Meeting Minutes	03 Jun 2016
	Vendor Weekly Report	10 Jun 2016

Figure 5: *Quality assurance documentation*

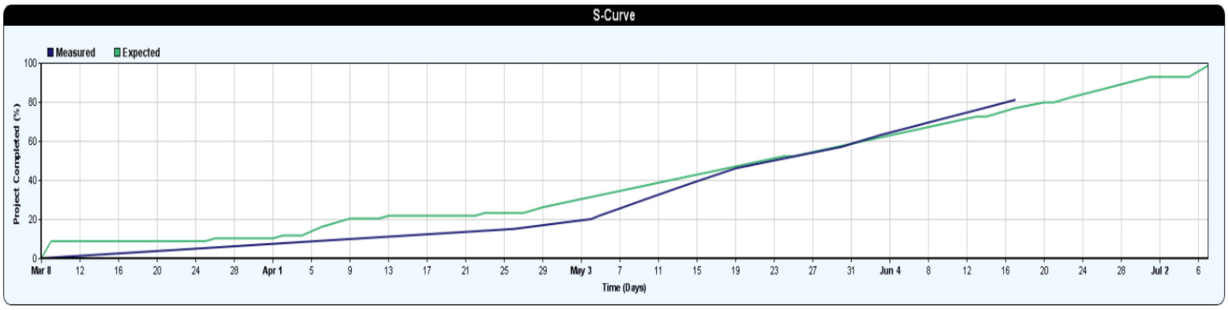

Figure 6: *Repair tracking against the gantt chart*

After the components have been surveyed and catalogued, they are available to be assessed for repair. (This is normally conducted as part of the strip and assess to understand the repair scope). Repairs are effected in accordance with the specification and with reference to the inspection and test plan and the project gantt chart.

Before re-assembly, the components are subject to a series of tests including integrity checks, insulation tests, and rotor balance to ensure the repairs have been effective and the qualifying the components compliant as repaired.

During re-assembly a build record for the machine is collated that includes objective measurement of bearing alignment, baffle and seal clearances, airgap concentricity and axial location of the rotor inside the stator. These aspects are fundamental for ensuring operational integrity of the motor.

The motor is then signed off for a no load run and dynamic assessment at full speed and voltage. Absorbed power, balanced currents, low overall operating vibration levels, sealing of bearings and air circuits, no load speed and the general operation of the motor to a steady state temperature is then conducted to qualify the motor operating integrity.

Figure 7: *motor on test field*

The final step is a quality assurance inspection to qualify that the motor as finished is appropriately painted has corrosion protection, shaft locks, terminal box seals, desiccators as appropriate and has is acceptable to return to site to resume service.

The advantage of the controls outlined in this paper will deliver savings on offsite repairs simply through control. Evidence shows that controlled maintenance compared to uncontrolled maintenance delivers a cost saving of up to 45% to the business.