The State of Non Destructive Testing in Zambia

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Abstract
Non Destructive Testing (NDT) finds wide application in the Zambian Copper Mining Industry, mainly for the statutory testing of mine winding engine components, cage suspension gear and rope attachments. Other applications include maintenance/repair aid testing of miscellaneous equipment and quality assurance testing of new equipment parts and fabrications.

Prior to the privatisation of the mining industry, there was one centralised NDT facility in the country owned by the mines. This paper describes the operation of this facility, covering methods and test procedures, equipment and training as well as qualification of personnel employed.

After privatisation of the mining industry, the centralised NDT facility was sold to new owners whose interests or core business was other than NDT resulting in a slow down in the development of the service in terms of equipment and manpower development. Several other NDT units emerged on the scene trying to meet the demands of an ever growing market due to the opening of new mines and other industries. The paper discusses the challenges paused by this state of affairs and the steps that should be taken to address them and thereby ensure an acceptable standard of NDT service in Zambia.

1. Introduction

In the early 1970’s, the two mining companies in Zambia, Nchanga Consolidated Copper Mines and Roan Copper Mines (which were later merged into Zambia Consolidated Copper Mines (ZCCM)) formed a joint testing house called Mining Industry Technical Services (MITS) to offer various testing services. The testing services included Non destructive Testing, which was initially solely for the mining industry but was later extended to mining suppliers, contractors and allied companies.

NDT in the Zambian mining industry gained prominence following the Markham Colliery disaster in the United Kingdom in 1973. NDT of mine winding engine components, winding rope attachments and cage suspension gear was made mandatory by the Zambian Government through the Mines Safety Department. Two codes of practice; “Code of Practice for the Non Destructive Testing of Winding Rope Attachments and Cage Suspension Gear” and “Code of Practice for Non Destructive Testing of Winding Plant” were drawn up based on the UK National Coal Board specifications.

2. NDT logistics and operations

The NDT Test Centre was located at Kalulushi which is central to the Copperbelt. The facilities were accommodated in custom built workshops.
2.1 NDT techniques and equipment employed

The following NDT techniques and equipment were used for testing at the centre and on site. No expense was spared as far as equipment was concerned and the Test Centre always kept abreast with international trends.

2.1.1 Magnetic Particle Inspection
A bench unit (see figure 1) with fixed coil, prods, ultra violet inspection lamps, fluorescent ink tank with turbulent circulation tank and component handling was used for testing at the Test Centre.

![Figure 1: MPI test bench at the Test Centre.](image)

Portable coils, articulate leg electromagnetic AC yokes and ultra violet inspection lamps were employed for base and on site testing services. Adequate stocks of bulk and aerosol kits of contrast aid paint, black and fluorescent ink were maintained.

2.1.2 Penetrant Inspection
Bulk and aerosol kits were used for base and on site testing requirements.

2.1.3 Ultrasonic Testing
Ultrasonic flaw detectors and digital thickness gauges were employed.

2.1.4 Radiographic Testing
Cobalt 60 and Iridium 192 isotopes and x ray units purposely built reinforced concrete exposure bay, base and mobile dark rooms.

2.2 NDT application

NDT fell into two categories, statutory testing and general testing:-

2.2.1 Statutory Testing
This was divided into the testing of mine winding engine components covered by the “Code of Practice for Non Destructive Testing of Winding Plant” and the testing of winding rope attachments and cage suspension gear covered by the ‘Code of Practice for the Non Destructive Testing of Winding Rope Attachments and Cage Suspension Gear’
2.2.1.1. *Mine Winding Engine Components*

This covered equipment sub-assemblies which included main drives, structural, brakes and head frame.

Where equipment spares were available, components were delivered to the Test Centre. On site testing was restricted to components for which it was not practical to transport to the Test Centre or where spares were not available. In the later case, tests were done during planned maintenance windows and great effort was made to achieve the required testing parameters, such as the use of canopies during fluorescent magnetic particle inspection. In both cases the mine had the responsibility of preparing items for examination, and the Test Centre was responsible for testing and reporting.

The code of practice stipulated that registers of tested components, unique to each mine, be maintained by the Test Centre for ease of traceability of component history. The test certificate produced also served as a computer input document for the Winder Indexing System (WIS). The WIS was devised as a database for use by both Test Centre and mine maintenance planning personnel. Periodically, compact print outs of updated records would be produced, such that on a subsequent examination, a component test history would be traced back by its unique number.

The WIS also had provisions for prompting maintenance personnel on components that were due for examination and their locations on a particular winding engine.

2.2.1.2. *Mine Winding Rope Attachments and Cage Suspension Gear*

This is the equipment located on the conveyance end of the mine winding system used for the transportation of personnel, equipment and material from underground to surface and vice versa. Failure of a system component can usually result in catastrophic loss of life, equipment and/or production, more so for single line arrangements.

The code of practice stipulated that the equipment components due for testing be itemised, identified, have adequate surface preparation (sand or shot blasting, preferably) and be transported in a defined transportation pallet to the Test Centre. The role of the Test Centre was to do the final preparation (degreasing), carry out appropriate tests and compile the reports.

Testing, for example fluorescent magnetic particle inspection, was conducted under controlled lighting conditions, with suitable handling equipment for efficiency and safety purposes. Tests were carried out by suitably qualified and experienced practitioners. In order to maintain consistent quality testing standards, there was no provision for onsite testing.

Defective items were retained at the Test Centre, pending destruction to avoid accidental re-installation

Test records were meticulously kept for reference and trend monitoring purposes.
2.2.2 **General Testing**

This consisted mainly testing of miscellaneous components during equipment overhaul, plant shut downs and after repairs. Testing was also done as part of quality assurance testing of new equipment parts and fabrications being supplied to the mines. The list of components included steel pipes, boiler shells and tubes, engine blocks, hoisting equipment, etc. This testing service was provided to the mines, mining suppliers, contractors and allied companies. The non mining companies serviced included sugar, cement and fertiliser manufacturers as well as an oil refinery.

Test records were maintained under defined categories and all components were assigned a permanent identification number, traceable to a particular client.

2.3 **Human resource**

The Test Centre initially depended on expatriate labour as there were no local formal training facilities for NDT. Local practitioners were later introduced by recruiting college/university graduates with science or engineering qualifications and subjecting them to on-the-job training. Typically, undergraduates would do their industrial experience attachment at the Test Centre and if they demonstrated interest in NDT, they would be engaged upon graduation as NDT trainees. The trainees would work under the supervision of a qualified practitioner and be exposed to the various NDT techniques. The trainees’ performance would be assessed and they would eventually be assigned to specialise in either Ultrasonic or Radiographic testing in addition to being proficient in the surface testing techniques.

As part of their development programme, the trainee underwent industrial attachments with client mine departments such as mining, concentrator, refinery, boiler shop, machine shop, foundry and power generation to have first hand experience in how the components they test operated. This helped in the assessment of test findings when doing NDT.

The final part of the development programme consisted of attending formal NDT courses and examinations at United Kingdom training establishments such as the Welding Institute which led to PCN certification in techniques of specialisation. In between courses and examinations, the trainee would be attached to industries of interest like British Steel and National Coal Board (British Coal) and NDT services companies.

This human resource development programme was very successful and by the late 1980’s, all the expatriate labour staff had been replaced by local people.
3. Current state of affairs

Following privatisation of the mining industry which started in the late 1990’s, the joint testing house, MITS, was acquired wholly by a company whose core business was mineral sampling and analysis. As a result, the engineering testing services side of the business including NDT does not appear to have benefited from additional investment leading to stagnation in equipment capitalisation and human resource training and development. For instance, the only radiographic equipment available in the country at the moment was purchased prior to the privatisation of the mining industry. A purpose built radiographic exposure bay has fallen into disuse (see Figure 2).

![Figure 2: Radiographic exposure bay no longer in use](image)

This stagnation of NDT development by the main operator and the opening of new mining companies have given rise to the emergence of new NDT units. Unfortunately, some of these new units have no established operating systems and are staffed by inexperienced practitioners with no formal training. In some instances, people who used to play supportive roles under MITS are now playing leading roles, albeit without the acquisition of any further training.

Lack of NDT training facilities locally has meant that there is no formal training of NDT practitioners. Outside the country training as used to happen previously is too expensive for the current much smaller units. There is also the fear that if one unit trains its practitioners, they will be “poached” by the other units.

The codes of practice for statutory testing do not appear to be strictly adhered to. The requirement for statutory testing to be carried out at a test centre where the conditions are ideal is not followed. There is a significant increase in on-site testing under make shift conditions.

There has also been a significant misinterpretation of the codes of practice, resulting in inconsistencies in both testing and administrative procedures. There is no centralised test database and information interchange amongst the various NDT providers. There also appears to be a lack of NDT knowledgeable representation on the client end and in many cases it is left to the NDT provider to determine inspection acceptance criteria.
Whereas previously there was sufficient local capacity and knowhow to provide all the NDT in Zambia, the situation now is that some of the NDT is being imported into the country, especially from South Africa.

4. Conclusion

To address some of the challenges being faced in the provision of NDT services as highlighted above, efforts are under way to form an NDT Association under the Engineering Institution of Zambia which is the regulatory body for all engineering practice in Zambia. The Association in conjunction with the government Mines Safety Department and Factories Inspectorate will publish guidelines regarding the requirements for NDT practitioners and facilities. It will maintain registers of approved facilities and practitioners and carry out audits to ensure all NDT providers are adhering to the guidelines.

Support from the wider NDT community especially in NDT training will be needed to ensure there is an acceptable standard of NDT service in Zambia.