MINERALS COUNCIL
SOUTH AFRICA

CRITICALITY OF COLLISION PREVENTION SYSTEM (CPS) TESTING

1 BACKGROUND

The commencement date of the suspended clauses, that is, Regulation 8.10.1.2(b) and 8.10.2.1(b), which required the automatic slow down and stop of diesel-powered trackless mobile machinery (TMM), in the TMM Regulations was gazetted on 21 December 2022. This date is also the effective date as per Gazette No. 47790, Vol 690, Government Notice No. 2908. For context, this gazette must be read in conjunction with Government Gazette No. 38493 published on and dated 27 February 2015.

In view of these developments, the Minerals Council adopts a common, member-differentiated approach to help members comply with the gazetted TMM Regulations. On the advocacy front, the Chairperson of the CEO Zero Forum continually engages with the Chief Inspector of Mines in high-level heartfelt conversations, while the Minerals Council technical teams engage in technical discussions with various role players bilaterally and collectively.

On the investment front, testing for technology readiness remains the most critical issue and takes considerable time. To this end, the Minerals Council technical expert teams continue to support members and other stakeholders in line with the Board's mandate of accelerating testing that:

- is performed under well-controlled conditions,
- uses appropriate test equipment,
- uses experienced human resources to conduct the tests,
- takes account of well-defined industry test procedures to ensure repeatability.

2 CRITICALITY OF TESTING

A CPS is a very complex system that must not be oversimplified as it is a safety system as per Annexure 1 below. It is technically, extremely difficult to upgrade Level 7 system to Level 9 system and to integrate that fully into the company management systems. Upgrading of legacy equipment, interoperability, electromagnetic interference, electromagnetic compatibility, and related ramifications such as legal liability, environmental conditions on the mines, installation, repair, and maintenance skills

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capacity, intensive change management necessary for sustainable adoption of technology, unintended consequences of impact of technology on people, etc, all add to the complexity. Being a safety system, the consequence of a non-functioning CPS is significant and can be very catastrophic. It is against this backdrop that:

a) Testing for technology readiness remains the most critical issue, takes considerable time, must be well planned and fully resourced.

b) Testing is the primary method of verification and quality assurance of CPS products to ensure that the CPS functions in accordance with the specified functional and performance criteria.

c) User requirements specifications have been developed through the Minerals Council special project defining several specific operational scenarios that the CPS products need to be able to deal with.

d) Testing and verification of conformance to the Functional and Technical Performance Requirements of CPS products developed through the Minerals Council special project is key.

e) Following the correct process and procedures for CPS testing cannot be over-emphasised.

2.1 Testing Principles

The most sensible approach to CPS testing is explained through the following testing principles:

a) Test at the lowest TRL level possible, prioritising TMM testing at TRL 4.

b) Test as early and as soon as possible.

c) Test with minimum interruptions to mining activities.

d) Build on existing MOSH test guidelines.

e) Conduct a gap assessment to identify and address the gaps.

f) Use stage gates to minimise the safety risks while gaining confidence that the system can do what it is expected to do.

g) On-mine testing (TRL 7 and up) must be performed in an environment that closely resembles an operating environment and requires the use of fit-for-purpose TMMs and authorised TMM Operators. Both the machines and the Operators must be removed from production based on a well thought out testing plan.

h) Collision Warning and Avoidance System Device (CxD) testing for underground can start as soon as CxD providers have demonstrated readiness at TRL 3 and TRL 4.

2.2 Testing Protocols

The integrated CPS testing regime was designed such that CPS testing follows a systematic stage-gate process towards compliance. It incorporates a third-party verification process to ensure that essential elements of testing are certified against the functional criteria that is set out. In an attempt to assist mines and their suppliers a high-level list of 24 CPS tests is provided in document titled: *"List of CPS Tests"* dated 10 March 2023. This list outlines the various aspects of the tests in terms of:

- test protocol name
- technology readiness level of the test (TRL)
- test objective
- test site

The stage-gate testing methodology ensures that CPS developers are proving conformance of their products from the early phases of development. This ensures that the downstream testing and integration on trackless mobile machinery (TMM) will follow through with less or no complex functional issues. Proving functionality at the lower technology readiness levels (TRLs) will assure active conformance and less implied risk with respect to failing the subsequent stage-gate tests and resultant financial losses. The testing conformance to the sequential TRLs also assists suppliers with the due-diligent and timeous preparation of their Section 21 files.

The CPS testing specifications are found on the Minerals Council's MOSH website: CPS Testing Specifications

2.3 Mine Testing Options

The CM&EE TMM Task Team working groups for the different types of mining processes, including underground hard rock, opencast, quarries and underground coal working groups were formed. Robust discussions through breakaway sessions culminated in the Minerals Council team developing a set of different CPS testing options for the South African Mining Industry (SAMI). This was necessary to facilitate and assist the SAMI in expediting their CPS testing plans with all the relevant stakeholders including their suppliers. Typical options which should all be mine-driven in partnership with their suppliers include every mine testing for itself and collaborative testing at commodity or regional level or per mine-type.

2.4 Testing Misconceptions

Through various engagements with different stakeholders, it has emerged that there is a misconception about the various types of testing that are undertaken by the SAMI. Notably, demonstration and development CPS testing is confused with CPS functional and verification testing. It is therefore very important to define these different types of testing to eradicate this misconception and the resultant false interpretation of testing conformance.

- **Demonstration test:** testing for proving specific functionalities by means of testing these elements on the field with minimal to no inclusion of measured and stored data.
- **Development test:** This testing is aimed at only proving the technological development element functionality and not the holistic CPS. For an example, filtering out electromagnetic interferences via a novel methodology on CxD and not a conventional test.
- **CPS compliance test:** the required CPS functional and verification testing is that which is done in accordance with the CPS technical documents developed through the Minerals Council project with specific reference to the test specification document. This entails a due diligent process that encompasses quantifiable and measurable data acquisition with fit-for-purpose instrumentation by qualified people.

The CPS testing specifications are found on the Minerals Council's MOSH website: CPS Testing Specifications.

2.5 Lessons Learnt from Recent Demonstration and Development Tests

The following are recurring lessons learnt:

a) There is sometimes a disconnect between mines and suppliers with respect to the CPS testing requirements. It is necessary that mines and suppliers should be aligned on CPS testing requirements.

b) Development testing is being done as a form of actual CPS compliance testing.

c) Mines should actively drive CPS testing with suppliers instead of relying completely on suppliers. This should include witnessing conformance to tests that are conducted.

d) Sub-standard test machines should not be used for testing. If this is allowed, it will lead to an inefficient and costly testing process such as incomplete test functionalities and failing conformance criteria.

e) Mines and suppliers are urged to follow industry agreed test protocols, approach and principles to the letter.

2.6 Quality Assurance and Effectiveness of CPS as a Safety System

The only way a CPS can be implemented with correctness is by means of it undergoing thorough functional compliance tests and conforming to the set functional criteria. The third-party verifier's involvement in assuring specific CPS functionality at the relevant stage-gate test points is imperative. A fully compliant CPS installed on a machine can only be effective if its operational lifecycle encompasses a rigorous installation, repair, and maintenance (IRM) strategy that is executed meticulously throughout the product lifecycle. The Annexure below explains how the various sub-systems of a CPS interface to prevent TMM collisions,

3 CONCLUSION

Mines are urged to ensure that testing:

- is performed under well-controlled conditions,
- uses appropriate test equipment,
- uses experienced human resources to conduct the tests,
- takes account of well-defined industry test procedures to ensure repeatability.

ANNEXURE 1: CPS AS A COMPLEX SAFETY SYSTEM

The illustration below seeks to, at a high and simplified level, define what a collision prevention system is and the main sub-systems that it comprises:

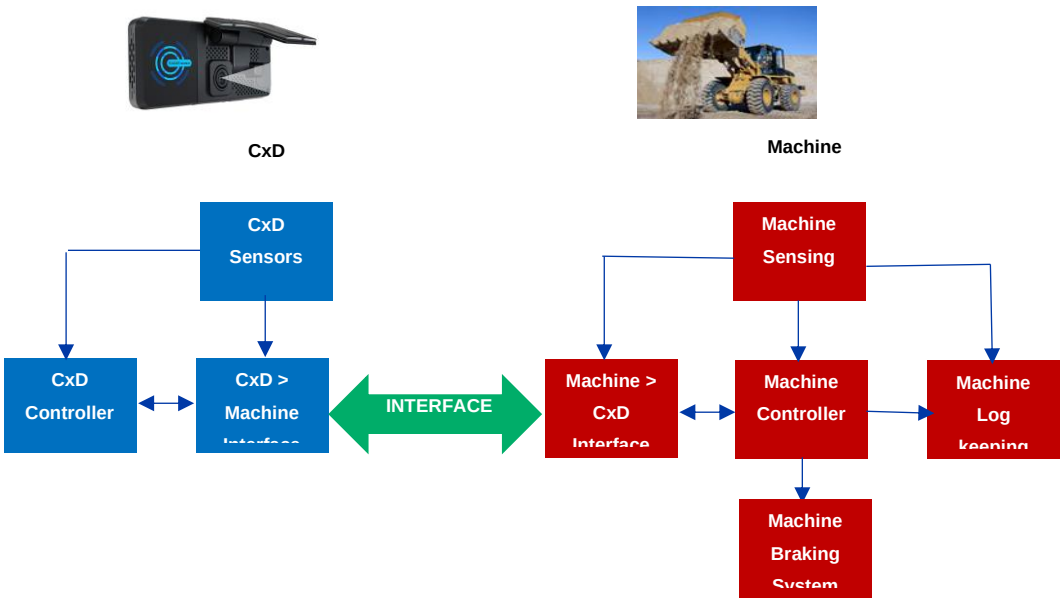

Figure 1: Collision Prevention System

The Collision Detection and Warning Device (CxD) Controller is the brain of the CxD. It is the component that makes the decision whether the machine (TMM) must slow down, stop or continue with normal operations. It makes these decisions based on information received from its sensors (e.g., GPS, GNNs, Radio, ToF, LiDAR, cameras, etc). Since some of these sensing technologies cannot operate on their own, a combination of these sensing technologies may be required to form a sensor "fusion". The CxD controller also gets information from the machine side via the interface. The ISO21815:2-2021 interface is the preferred standard interface which has been widely recommended. This decision that the CxD makes is then communicated via the interface to the machine. This instruction is given to the machine controller (which is the brain of the machine) which then decides what the best possible action

to be taken is. It will also get information from the normal machine sensing devices like payload, angle of inclination, pitch, roll, etc. Given all these inputs, the machine controller then needs to decide whether to apply the retarder (in HME trucks), apply the service brakes, apply the emergency brake, etc. so that the machine can be brought to a safe stop.