Introduction:

As a result of many customer complaints from the field and our own intensive analysis of the electronic igniter for setting tool, it was decided that a re-design of the contact assembly and crimping mechanisms was absolutely essential in order to provide a reliable product which functioned fail-safe.

The electronic components of the igniter were not changed in any way so that none of the RF safety functions of the igniter would be compromised.

The following is a list of the problems which existed within our old design of the EIST which needed to be corrected.

1. Complete separation of copper shell from contact assembly piece immediately after ignition (referred to as **"Fly-Off Effect"** hereafter)
2. The base of the copper shell does not break away from the main shell body, after attempted ignition, thus preventing a successful ignition of the gun powder in the setting tool. This has been repeatedly proven to be directly caused by the "fly-off effect"
3. An unintentional by-pass connection or short circuit was often caused by poorly soldered positions or flux agent residues at the circular circuit board.
4. Short Circuits, in contact assembly head, due to lack of insulation at certain weak points and also faulty o-rings which do not insulate properly at elevated temperatures.
5. The actual measured resistance of the EIST had shifted by approximately 1kOhm due to the fact that a new electronic EZE element had been implemented in a previous design. This meant that the electronic detonator tester would indicate that many of the igniters sent to customers were "Not OK" due to the fact that most of them had a resistance which lay outside the measurement range of the detonator tester.

Measures taken to solve problems:

1. A complete redesign of the contact assembly piece was necessary to allow for a double crimp mechanism of the copper shell to the contact assembly piece. Two grooves were introduced to the contact assembly piece which accommodated the double crimp. This method was proven during intensive testing to completely eliminate the “fly-off effect”. See Fig.1 below.

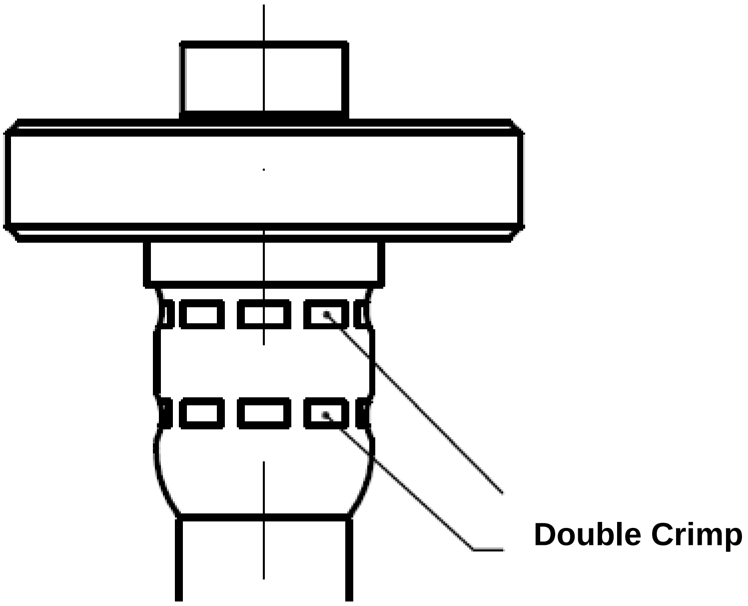


Fig1. Re-design of contact assembly piece, to allow for a double crimp of copper shell.

2. By eliminating the “fly-off effect”, the problem due to the base of the shell not flying away directly after ignition, was automatically solved. Repeated tests where the shell was held mechanically in place had proven that whenever the shell and contact assembly remained together there are never problems with the base of the copper shell.

3. A clamping fixture was designed and built to allow the personnel in the igniter manufacturing facility to solder more efficiently without creating unwanted short circuits during assembly. A cleaning agent is now also used during assembly to remove any unwanted flux residue resulting from the solder contact points.

4. As previously mentioned; short circuits and, more frequently, faulty o-rings had been a major problem with our previous contact assembly. To address this problem and also to create more flexibility and reduce our dependence on one single supplier, a redesign of the contact assembly was undertaken. The parts for the new contact assembly heads are now locally manufactured and assembled.

In the new design shown, a total of 400 assembly pieces have been assembled to date, by the igniter production unit. There have been zero defective assembly pieces detected through the resistance measurements.

5. A new electronic detonator tester II was developed by the company Antares. The measurement range was adapted so that all electronic igniters which had a resistance between 9,2kOhm - 13,8kOhm would be indicated as being O.K. This meant that correctly assembled igniters could be efficiently checked during production. A number of electronic detonator tester II have been released to customers, so that they can verify that their EIST's are functioning properly.

Testing & Qualification:

A total of 100 EIST prototypes were assembled for the internal qualification.
These electronic igniter prototypes were to be exposed to a number of testing conditions including: shock impact tests, drop tests, vibration tests, electrostatic discharge and various temperature change cycles.

During all of the testing, an unintentional ignition of the EIST during exposure would mean an immediate failure of the qualification. This did not occur with any igniter.

After all exposure cycles every EIST was ignited intentionally with a firing panel to check for functionality either at room temperature or 155^{o}C.
The chart below (Fig. 4) shows how many igniters were tested and the corresponding type of exposure conditions. After the exposure, all Igniters (with the exception of those which had undergone the ESD tests) were still functional and could be ignited without any problems either at room temperature or at 155^{o}C in side the heating cabinet. A new testing fixture was designed and assembled to allow for a full function test of the igniters. A number of pressed gun powder pellets were successfully ignited at a distance of 50mm from the base of the EIST shell to surface of the pellets. (See Fig. 2 for Set-Up). A lead witness plate was screwed directly behind the pellet to confirm the successful ignition.

10 pellets were ignited at 155^{0}C and 10 were ignited at room temperature. The test fixture also allows for electrical connection the EIST using a spring loaded pin and screwing mechanism.

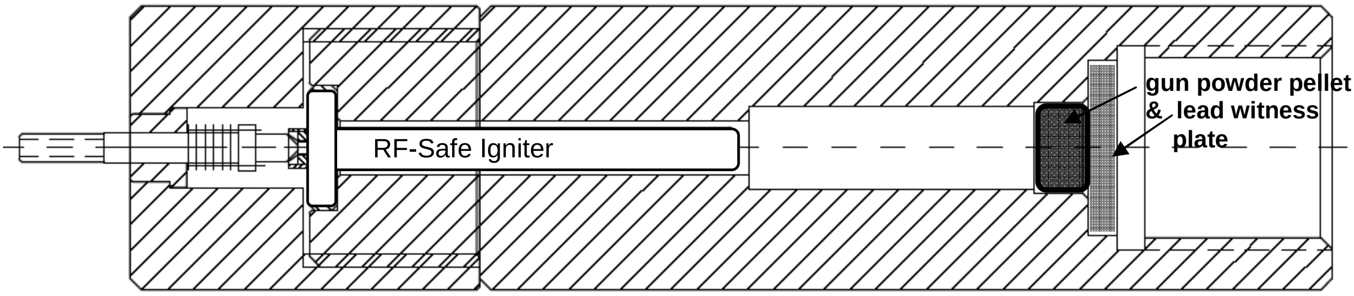


Fig.2 Test Set-Up for testing of successful ignition between EIST and gun powder pellet.

From all igniters which were fired not one single copper shell had been separated from the contact assembly. The "fly-off" effect did not occur in any case. The igniter shell and the contact assembly head did not show any signs of deformation after being shot.

Fig.3 Igniters are not deformed and no signs of fly-off effect after shooting

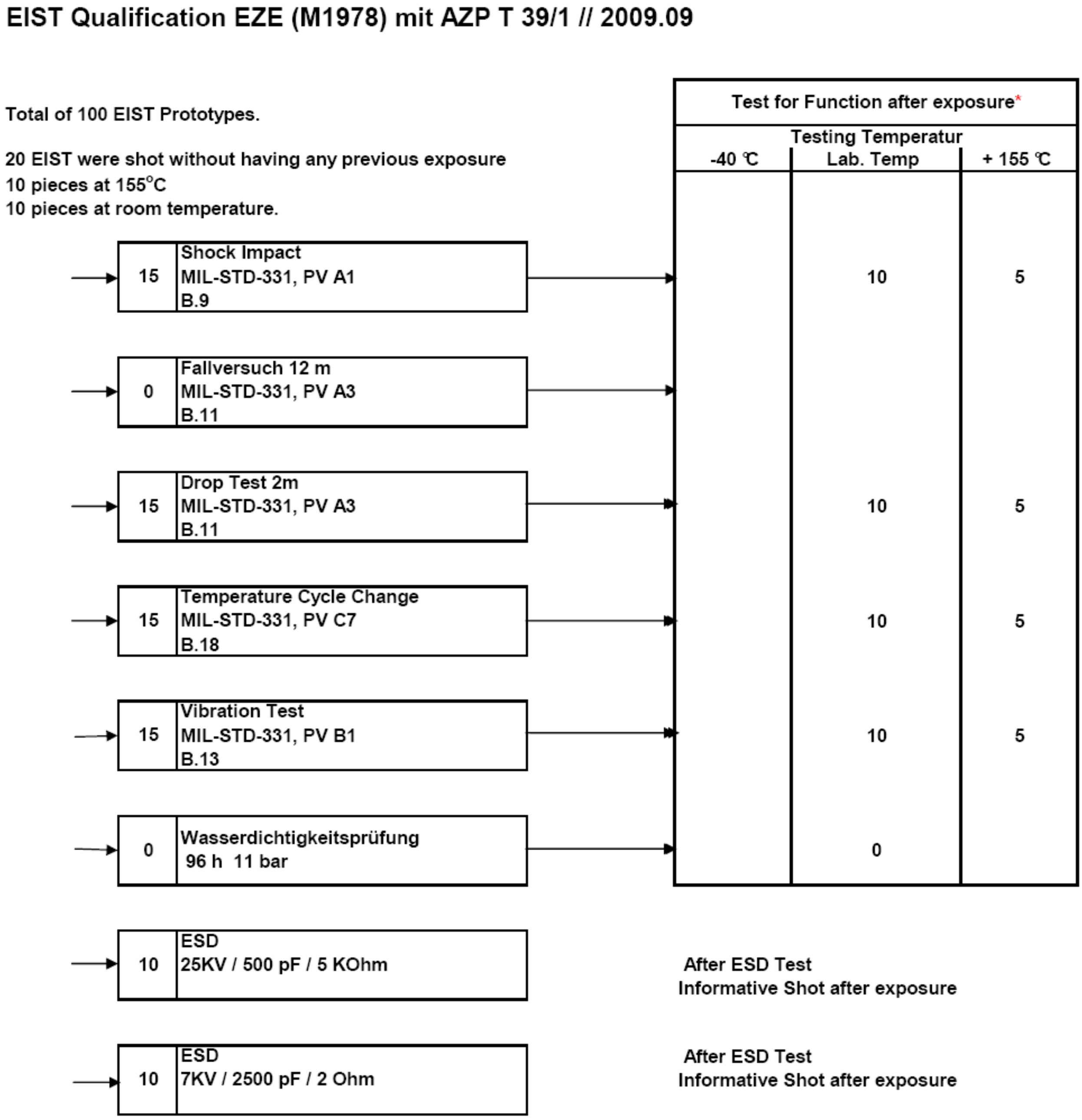
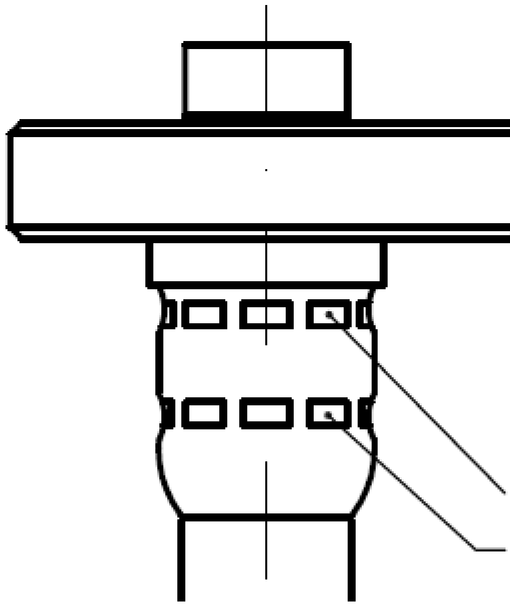


Fig. 4 Qualification Programme of 100 EIST Prototypes.

General Remarks & Conclusions:

Close monitoring of EIST production in the near future is strongly advisable to detect any weak aspects which may have been overlooked.
One important point is the sequence with which the crimping takes place. If the copper shell is to be crimped manually, the groove marked position1 must be crimped first before the crimp at position 2. If position 2 is unintentionally crimped first, it may push the copper shell away from the contact assembly piece by a distance of 0,5mm. This may cause a breakage in the small circular board contact and lead to a defective connection inside the EIST. This has been observed during production and cause approximately 15 pieces to be rejected.
Since the correct crimping sequence has been strictly observed no pieces have been rejected after being crimped. The last sequence of 100 EIST pieces from the last production run showed no contact rejections.



A new crimp chuck powered by a hydraulic aggregate is presently being designed which will perform the double crimp in one action albeit with Pos.1 contacted first.
This re-designed crimp chuck should allow for a vastly improved crimp connection between the copper shell and main assembly body by applying a greater force which is always reproducible.
The vastly improved crimp may also allow for a re-implementation of the mechano-tech contact assembly pieces which are presently in stock but not cleared for production use.
The new hydraulic chuck will be intensively tested before being introduced to the production unit.

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DYNAenergetics GmbH & Co. KG

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