

UNITED STATES DEPARTMENT OF LABOR
Mine Safety and Health Administration

**EVALUATION OF THE ORICA UNI TRONIC™ (Model 335 and 500)
ELECTRONIC BLASTING SYSTEM--REQUIREMENTS FOR SHUNTING
AND CIRCUIT TESTING**

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By

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1. Purpose

MSHA has received inquiries about how the requirements for shunting and circuit testing in the Title 30, Code of Federal Regulations (30 CFR) are applied to electronic detonators. The purpose of this specific report is to discuss the technical findings and

the issues of “shunting” and “circuit testing” for the Orica UNI Tronic™ electronic detonator systems (Models 335 and 500) with regard to the 30 CFR requirements.

With respect to **electric** detonators, the coal and metal-nonmetal mine requirements for shunting and circuit testing are specified in 30 CFR 77.1303 (y)(1),(2),(3) and 77.1303(z); 56.6401(a),(b),(c); 56.6407(a),(b),(c),(d) and 57.6401 (a),(b),(c) and 57.6407 (a) and 57.6407 (b). **Electric** blasting systems are designed differently than electronic detonator systems and the design features are not the same. Each electronic detonator system differs in design, construction, operation and testing features.

To resolve the issue of “shunting and “circuit testing”, technical information was reviewed and evaluated on the Orica UNI Tronic™ Model 335 and 500 electronic detonator systems.

2. Introduction – Using Electric Detonators

Electric detonator systems for performing blasting operations have been in use in the mining industry for many decades. They are used in both series and parallel blasting circuits. All electric detonators produced in the USA have shunts on the free ends of the leg wires. The shunt provides a low resistance path to prevent current from flowing through the bridge wire of the electric detonator. With a shunt both of the leg wires are at the same potential to prevent extraneous current flow into the detonator. In addition, some designs completely enclose the ends of the wires in order to prevent corrosion and to prevent bare wires from contacting extraneous electrical current sources. The shunt is removed when an electric detonator is connected into the blasting circuit. Electric detonators are supplied with a distinctive, numbered tag to facilitate easy identification of the delay period.

Since electric detonators are designed to fire when electrical energy is supplied to them, any extraneous source of electric current represents a potential source for initiation. Sources such as lightning, high voltage power lines, radio transmitters, and static electricity must be avoided. There are also occurrences where the energy from lightning has traveled several miles along pipes or cables into an underground mine and can represent an unsuspected source for initiation of electric detonators.

When using electric detonators, the continuity and resistance of the individual detonator as well as the entire circuit needs to be tested with a blasting galvanometer. A blasting galvanometer is used to check the individual detonators prior to making the primer and again prior to stemming the borehole. Care should be taken when stemming a borehole to prevent any possible damage to the detonator leg wires. Once the circuit is completely wired, it should be checked again. When the blast line is connected to the circuit, the resistance needs to be checked prior to connecting the blasting unit.

When electric detonators are initiated, current leakage from the blasting circuit must also be prevented. If bare wires are allowed to come into contact with another conductor or even a conductive portion of the ground, some of the electric energy may leak out of the circuit causing misfires.

3. Technical Discussion

An electric detonator consists of two leg wires embedded in a metal shell which contains a high explosive base charge designed to initiate other explosives. Electric detonators are typically designed with an ignition mixture, a pyrotechnic fuse train (for the delay element) and a base charge, respectively (See Figure 1). A thin metal filament, known as a bridge wire, is attached between each end of the leg wire and is embedded in an ignition mixture. The pyrotechnic delay element is designed to burn at an approximated rate. The length and composition of the pyrotechnic train control the approximate rate of burn and thus the timing of when the detonator fires. Since the approximate rate of burn is subject to variation, the firing time accuracy of the electric detonator is affected. When sufficient electrical current passes through the bridge wire, it becomes hot enough to ignite the ignition mixture. This event initiates the pyrotechnic element in the delay train which then initiates the base charge.

Electronic detonator systems are new technology advancements for the initiation of blasts in mining operations. Their introduction into mine blasting operations is beginning to advance. Several advantages for electronic detonators are precise timing, reduced vibrations, a reduced sensitivity to stray electrical currents and radio frequencies, and a great reduction in misfires through more precise circuit testing.

Electronic detonators have been designed to eliminate the pyrotechnic fuse train that is a component of electric detonators, thus improving timing accuracy and safety. For the electronic detonators, typically an integrated circuit and a capacitor system internal to each detonator separate the leg wires from the base charge. Depending on the design features of the electronic detonator, the safety and timing accuracy can be greatly improved. An example of the constructional features of an electronic detonator is shown in Figure 2. The electronic detonator is obviously a more complex design compared to an electric detonator. A specially designed blast controller unique to each manufactured system transmits a selectable digital signal to each wired electronic detonator. The signal is identified by each electronic detonator and the detonation firing sequence is accurately assigned. The manufacturer's control unit used in accordance with the unit's specified operating procedures will show any incomplete circuits during hookup prior to initiation of the explosive round. The wired round won't fire until all detonators in the circuit are properly accounted for with respect to the current blasting plan layout.

As part of the resolution of the “shunting” and “circuit testing” issues, a technical evaluation was made of the UNI Tronic™ Electronic Blasting System. UNI Tronic™ is a trademark designation and represents the electronic blasting system for the Model 335 and 500 as discussed in this report. In addition to evaluation of the technical documents provided by Orica, MSHA personnel observed the performance of a UNI Tronic™ blasting system at a surface mining operation.

Orica UNI Tronic™ Electronic Blasting System (Orica USA Inc.)

The basic components of the Orica UNI Tronic™ electronic blasting system, Model 335 and Model 500 are described in the following text. Photographs are presented to illustrate both models.

Orica UNI Tronic™ Model 335 (Orica USA Inc.)

The basic components of the UNI Tronic™ Model 335 are its electronic detonator assembly, the UNI Tronic™ Network Tester, UNI Tronic™ Scanner, UNI Tronic™ Blast Box, UNI Tronic™ Connector Leads and UNI Tronic™ Blasting Cable.

The UNI Tronic™ 335 detonator assembly as shown in Figure 3 is easily identified by its yellow legwire (cable), RCA connectors and unique barcode ID for each detonator. Each electronic detonator has an assigned traceable ID number held on the internal chip and printed on the RCA connector. The UNI Tronic™ Scanner is used to scan the bar code ID for each detonator and to enter the desired delay for each scanned detonator (Figure 4).

In preparing the round to be blasted, the UNI Tronic™ 335 electronic detonator is inserted into the booster creating a primer. The booster and electronic detonator are shown in Figure 5 prior to the preparation of the primer. The primer is then loaded into the borehole. Next, the borehole is loaded with the chosen blasting agent (Figure 6). Prior to stemming the borehole, the UNI Tronic™ Network Tester is plugged into each detonator and tested (Figure 7). During this step, the UNI Tronic™ 335 electronic detonator is systematically checked for short circuits, open circuits and legwire integrity. Once this check has been made, the UNI Tronic™ 335 electronic detonator is connected into the blasting circuit. The blasting circuit is checked again using the UNI Tronic™ Network Tester to test for continuity, leakage and polarity.

The order of connecting the electronic detonators or the sequence of connecting them does not affect the timing values. After the blast area is cleared, the lead-in wire is then connected to the UNI Tronic™ Blast Box. The UNI Tronic™ Scanner is then docked into the UNI Tronic™ Blast Box and its stored information (Detonator ID and delay times) is downloaded (Figure 8).

The blaster follows the screen instructions on the Blast Box as it assigns each detonator its final timing delay value. All of this information from the UNI Tronic™ Scanner is stored in the UNI Tronic™ Blast Box while the timing value is stored into the memory of the electronic detonator. The UNI Tronic™ Blast Box also checks for continuity, extra detonators, and for detonators that have faulty connections or no connections at all. This information is displayed on the blast box screen before the blast can be armed and fired. The information is then used to check against the blast plan. The UNI Tronic™ Blast Box unit will not arm the round until the system operational check is completed. Once the round is armed, the blaster can initiate the blast from the UNI Tronic™ Blast Box.

Orica UNI Tronic™ Model 500 (Orica USA Inc.)

The basic components of the UNI Tronic™ Model 500 are its electronic detonator assembly, the UNI Tronic™ Network Tester, UNI Tronic™ Scanner, UNI Tronic™ Blast Box, UNI Tronic™ Harness Wire and UNI Tronic™ Lead-in-Line.

The UNI Tronic™ 500 detonator assembly as shown in Figure 9 is easily identified by its yellow duplex legwire, yellow field connector and unique barcode ID (Flag Tag) for each detonator. Each electronic detonator has an assigned traceable ID number held on the internal chip and printed on the Flag Tag. The UNI Tronic™ Scanner is used to scan the Flag Tag (bar code ID) for each detonator and to enter the desired delay for each scanned detonator (Figure 10).

In setting up the round to be blasted, the UNI Tronic™ 500 electronic detonator is inserted into the booster (Figure 11). This primer is then loaded into the borehole. Next, the borehole is loaded with the chosen blasting agent. Prior to stemming the borehole, the UNI Tronic™ Network Tester is connected to each detonator and tested (Figure 12). During this step, the UNI Tronic™ 500 electronic detonator is systematically checked for short circuits, open circuits and legwire integrity. Once this check has been made, the UNI Tronic™ 500 electronic detonator is connected into the harness wire circuit. The harness wire circuit is checked again using the UNI Tronic™ Network Tester to test for continuity, leakage and polarity.

The order of connecting the electronic detonators or the sequence of connecting them does not affect the timing values. After the blast area is cleared, the lead-in wire is then connected to the UNI Tronic™ Blast Box. The UNI Tronic™ Scanner is then docked into the UNI Tronic™ Blast Box and its stored information (Detonator ID and delay times) is downloaded.

The blaster follows the screen instructions on the Blast Box as it assigns each detonator its final timing delay value. All of this information from the UNI Tronic™ Scanner is stored in the UNI Tronic™ Blast Box while the timing value is stored into the memory

of the electronic detonator. The UNI Tronic™ Blast Box also checks for continuity, extra detonators, and for detonators that have faulty connections or no connections at all. This information is displayed on the blast box screen before the blast can be armed and fired. The information is then used to check against the blast plan. The UNI Tronic™ Blast Box unit will not arm the round until the system operational check is completed. Once the round is armed, the blaster can initiate the blast from the UNI Tronic™ Blast Box.

A comparison of characteristics of the UNI Tronic™ Model 335 and 500 electronic detonator systems are presented in Table 1.

4. Surface Mine Field Trip Examination

A field trip was made to a surface mining operation to examine and witness the use of an Orica UNI Tronic™ electronic blasting system. The system detected open blasting circuits which enabled the blasting crew to specifically locate and correct the fault. This test indicates the systems ability to prevent misfires, thus minimizing a major safety hazard associated with blasting operations.

Surface coal mine visit. A visit was made to a surface coal mine operation in western Virginia to view the Orica UNI Tronic™ electronic blasting system in operation. The blast site contained 93 holes. The diameter of each hole was 9 inches and the depth was 50-60 feet. The electronic detonators and boosters were laid out and assembled. The UNI Tronic™ electronic detonator with its unique ID tag is shown in Figure 3. A one pound booster primed with an Orica UNI Tronic™ electronic detonator was lowered into each blast hole prior to loading with ANFO-emulsion blend from several bulk loading trucks (Figure 13). The “Network tester” was connected to the leg wire of each electronic detonator separately (shown in Figure 7). The circuit continuity and integrity were checked. Then each detonator was scanned with the bar code reader and the desired delay was entered into the bar code reader for that scanned detonator. For tracking, each detonator has a separate unique ID number already assigned at the factory.

In preparation for blasting, each primed blast hole is loaded with ANFO from a bulk loading truck and then stemmed (Figure 14). Once the whole round was scanned using the Orica bar code reader and then tested with the “Network tester”, all the detonators were then connected to the main firing line. The data from the bar code reader is then transferred to the UNI Tronic™ Blast Box. The delay time is stored in the internal chip of the electronic detonator and the bar code reader. The UNI Tronic™ Blast Box then checks the wired round for short circuits and unconnected firing lines, and missing or extra detonators. This test indicated that one hole, #92 was not registering as being connected. The UNI Tronic™ Blast Box had indicated the particular unconnected detonator and the detonator was located. This is an important feature, since it

prevented the occurrence of a misfire. Also the UNI Tronic™ Blast Box served the purpose of a blasting galvanometer by checking the continuity of the system.

Following a complete check of the blasting system, the blast area was cleared and the wired round was armed and fired with the Blast Box as planned. All the blastholes fired and the blast was successful. A photograph of the blast is shown in Figure 15.

The field trip to examine an actual blast showed that the Orica UNI Tronic™ electronic blasting system performed as intended. The diagnostic evaluation using the “Network tester” and the preblast diagnostic testing performed with the Orica Blast Box satisfied the MSHA requirement for circuit testing.

5. Conclusions

The shunting issue with respect to the UNI Tronic™ Model 335 and 500 electronic blasting systems was evaluated by technical and a field use examination. The means of shunting for the Orica UNI Tronic™ 335 and 500 electronic detonator is provided by their specific internal design and construction features unlike a shunt for a conventional electric detonator. Both of these electronic blasting systems have undergone extensive testing which included sources of stray and extraneous electricity and provide a higher level of safety than conventional electric detonators. The Orica UNI Tronic™ Model 335 and 500 electronic blasting system has an internal design for shunting within the electronic detonator and circuit testing with the “Network tester” and the Blast Box that meet the intended MSHA requirements. Therefore, the Orica UNI Tronic™ Model 335 and 500 electronic blasting systems do not need to be physically shunted and circuit tested by using a blaster’s galvanometer as would be performed for conventional electric detonators. Because of the unique design and construction of the UNI Tronic™ 335 and 500 electronic blasting system, they must be used according to the manufacturer’s instructions.

Consultation should be made with the MSHA Approval & Certification Center on subsequent change(s) to the Orica UNI Tronic™ electronic blasting system, Models 335 and 500 that may affect the requirements for shunting and circuit testing in the Title 30, Code of Federal Regulations (30 CFR). The change(s) may require reevaluation of the particular electronic blasting system.

6. Summary

Electronic detonator systems are one of the newer technologies being introduced into the mining industry. Their advantage is thorough pre-blast circuit testing and very precise detonator firing time. An integrated circuit chip and an internal capacitor system control the detonator initiation time. The electronic blasting systems observed have an unparalleled safety feature, since they cannot be initiated by a conventional

blasting unit. However, electronic detonators can still be initiated by lightning, fire, and impact of sufficient strength. It is anticipated that a decrease in the number of pre-detonations, misfires, and other unintentional initiations should result from the use of electronic detonator systems.

The design and operational features of the Orica UNI Tronic™ Model 335 and 500 electronic blasting systems have been technically reviewed and the field use has been observed at a mine site. The Orica UNI Tronic™ Model 335 and 500 blasting system have their own proprietary electronic design for shunting and circuit testing that meets the intended MSHA requirements.

This report is posted on MSHA's web site and may be accessed under Technical Reports at <http://www.msha.gov/TECHSUPP/ACC/ACCHOME.HTM>. Also, an MSHA Program Information Bulletin (PIB 04-20) on electronic detonators and requirements regarding shunting and circuit testing is available on MSHA's web site. The bulletin may be accessed at <http://www.msha.gov/regs/complian/PIB/2004/pib04-20.htm>.

Table 1--UNI Tronic™ System--Electronic Detonator Comparison

Characteristic	UNI Tronic™ 335	UNI Tronic™ 500
Delay Range	10,000 ms	10,000 ms
Delay Increments	1 ms	1 ms
Detonator Shell Type	Copper	Copper
Legwire Cross Section	Circular	Dumb bell
Legwire Conductor	Copper	Steel
Legwire Color	Yellow	Yellow
Tensile Strength (lbs)	77	44
Connector Type	RCA	Hinged IDT ¹
Connector Color	Various by Length	Yellow
Bar Code Location	Connector	Flag Tag
Unique ID	Yes	Yes
Blast Hook-up	RCA connector	Harness wire

Note:

1. IDT = Insulation Displacement Terminals

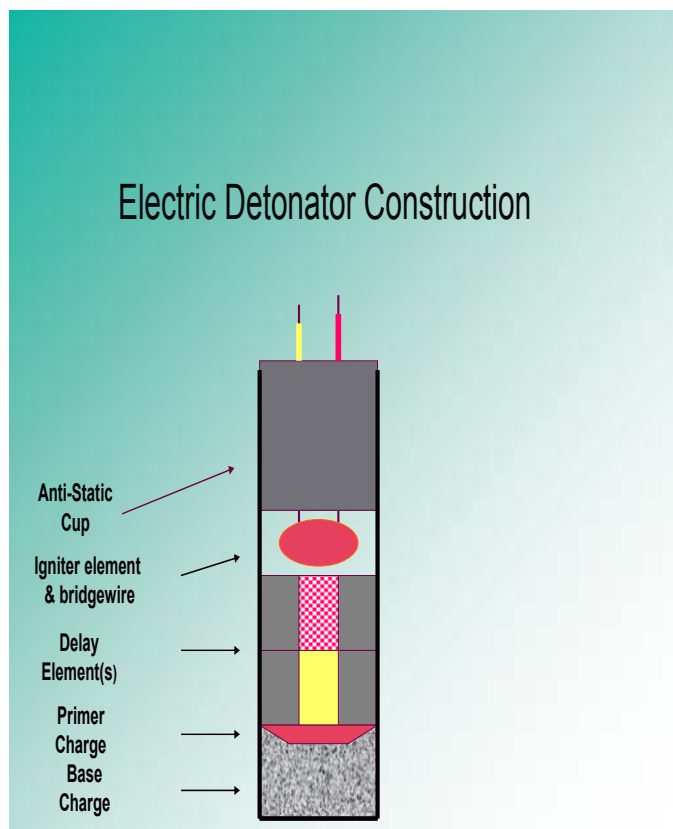


Figure 1 - Electric Detonator Components

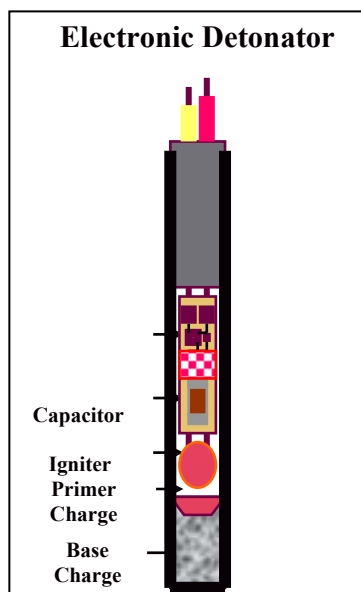


Figure 2 – Electronic Detonator Components

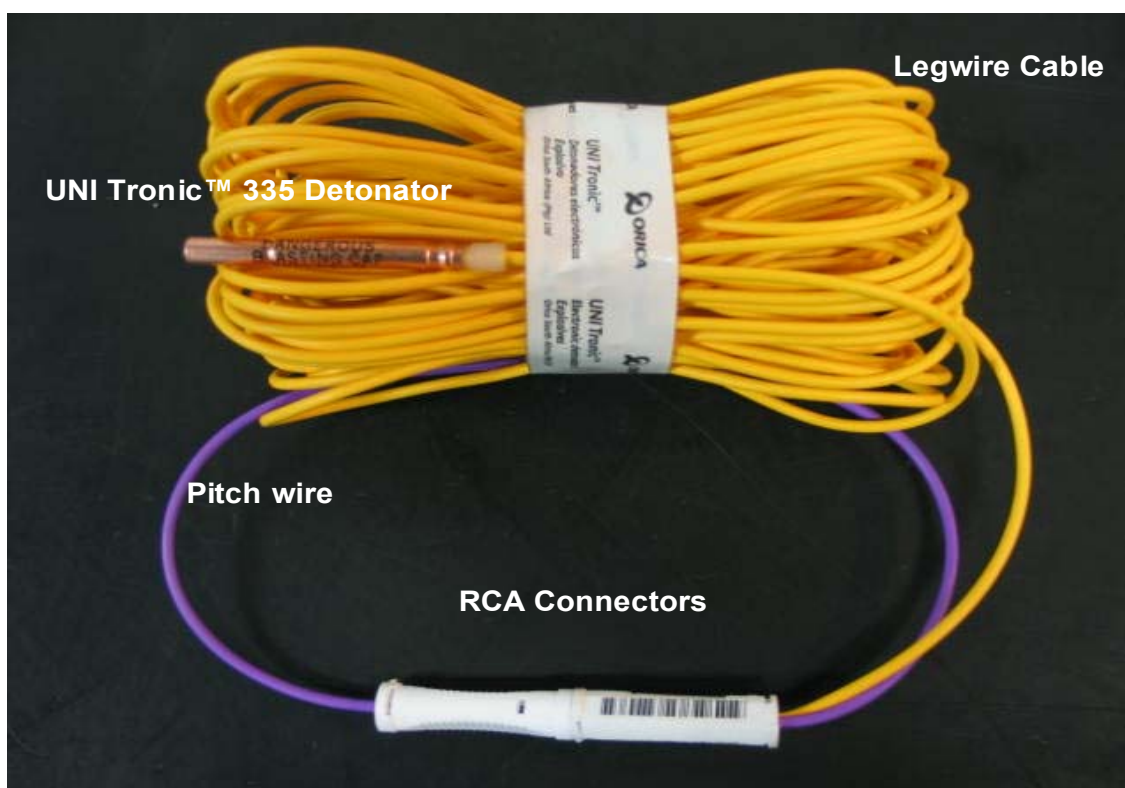


Figure 3 – Orica UNI Tronic™ 335 Electronic Detonator Assembly



Figure 4 - Orica UNI Tronic™ Scanner (Bar Code reader)



Figure 5 - Orica UNI Tronic™ 335 electronic detonator and booster



Figure 6 - Loading a blasthole



Figure 7 -- Orca UNI Tronic™ Network Tester



Figure 8 -- Orca UNI Tronic™ Blast Box with the Scanner inserted to download electronic detonator information

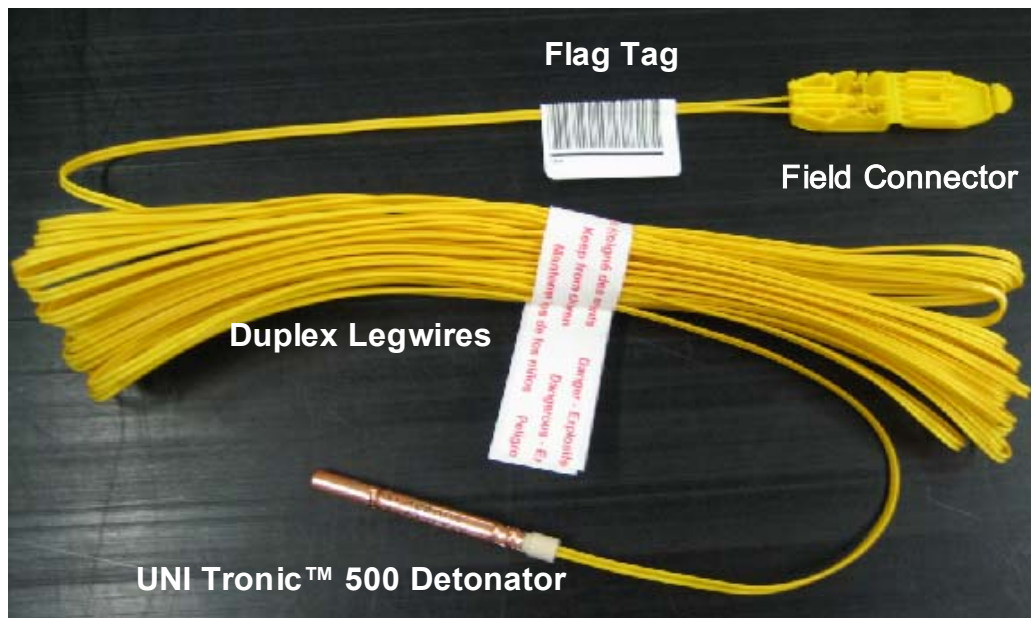


Figure 9 – UNI Tronic™ 500 Electronic Detonator, Connector and Flag Tag (bar code ID)



Figure 10 – Orca UNI Tronic™ Scanner used to read an electronic detonator (Unitronic™ 500) bar code ID



Figure 11 - Preparing a primer by insertion of an electronic detonator (UNI Tronic™ 500) into a booster



Figure 12 - UNI Tronic™ Network Tester used to test a UNI Tronic™ 500 electronic detonator



Figure 13 - Priming a blasthole with a booster prior to loading with ANFO-emulsion blasting agent



Figure 14 - Stemming a blasthole



Figure 15 – Firing of the blast at the mine site using the Orica UNI Tronic™ Blast Box