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MC4523 Sealed Cap: Component and Characteristics Development Report

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Prepared by
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MC4523 Sealed Cap

Component & Characteristics Development Report

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ABSTRACT

The MC4523 Sealed Cap is a WW42C1 Percussion Primer that is pressed into a steel cylinder. Hermeticity of the input end is then provided by welding a thin steel closure disk on the input end of the MC4523. Thus, the user is provided with a component that is prequalified in terms of ignition sensitivity and hermeticity. The first customer is the Thermal Battery Department (1522). The MC4523 will be used on the MC2736A Thermal Battery which in turn will be used on the W78 JTA. Attachment of the MC4523 to the battery is with a laser weld. Combined test results of four production lots at a commercial supplier (PPI, TMS, WR1, and WR2) show an all-fire ignition sensitivity (.999 @ 50%) of approximately 60 millijoules of mechanical energy with a 2.2 gram firing pin. The firing pin had an impact tip with a radius of 0.020 inch. This firing pin is like that to be used in the W78 JTA application. Approximately 112 millijoules of mechanical energy will be supplied in the application, thus the design margin is more than adequate.

ACKNOWLEDGMENTS

The principal members of the MC4523 Process Realization Team are given in the text. Besides the PRT, a number of individuals contributed to the successful MDE production of this component at a commercial supplier. The close relationship with the Battery Department, in particular Jim Gilbert and Greg Sharrer is greatly appreciated. Their partnership made this component possible. The support of the entire MDE infrastructure is acknowledged. The author would also like to acknowledge the assistance of Robert Parson (1552) in set up of the Variable Spring Tester and Barbara Frames (9681) for coordination of the Engineering Release Activity. At EG&G/Star City Inc., the efforts of Dave Haas, Carol Tibbitts, and Jim Edwards during the actual manufacturing are greatly appreciated.

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ACRONYMS & DEFINITIONS

AMB	<u>A</u> mbient
CCL	<u>C</u> ertified <u>C</u> alibration <u>L</u> aboratory
CTR	<u>C</u> ontrol
DA	<u>D</u> esign <u>A</u> gency
DOE	<u>D</u> epartment <u>o</u> f <u>E</u> nergy
EER	<u>E</u> ngineering <u>E</u> valuation <u>R</u> elease
ENV	<u>E</u> nvironmental
EQ	<u>E</u> ngineering <u>Q</u> ualification
EUO	<u>E</u> valuation <u>U</u> se <u>O</u> nly
GFE	<u>G</u> overnment <u>F</u> urnished <u>E</u> quipment
GFM	<u>G</u> overnment <u>F</u> urnished <u>M</u> aterial
IMS	<u>I</u> mage <u>M</u> anagement <u>S</u> ystem
JTA	<u>J</u> oint <u>T</u> est <u>A</u> ssembly
LAT	<u>L</u> ot <u>A</u> cceptance <u>T</u> est
MD	The two letter acronym for the Mound production site
MRB	<u>M</u> aterial <u>R</u> evue <u>B</u> oard
NBS	<u>N</u> ational <u>B</u> ureau of <u>S</u> tandards
NIST	<u>N</u> ational <u>I</u> nstitute of <u>S</u> tandards and <u>T</u> echnologies (formerly NBS)
PA	<u>P</u> roduction <u>A</u> gency
PPI	<u>P</u> rocess <u>P</u> rove- <u>I</u> n
PRT	<u>P</u> roduct <u>R</u> ealization <u>T</u> eam
QC1	The level of Quality Control previously mandated by the DOE for WR Product. This definition of quality has been replaced by EP401418.
QC2	A previous level of Quality Control that was used to qualify development activities within the DOE complex.
QER	<u>Q</u> uality <u>E</u> ngineering <u>R</u> elease
SCI	<u>E</u> G& <u>G</u> / <u>S</u> tar <u>C</u> ity <u>I</u> ncorporated
SCR	<u>S</u> andia <u>C</u> ontract <u>R</u> epresentative
SNL	<u>S</u> andia <u>N</u> ational <u>L</u> aboratories
STP	<u>S</u> tandard <u>T</u> emperature and <u>P</u> ressure
SXR	<u>S</u> pecification <u>E</u> xception <u>R</u> elease
TMS	<u>T</u> ool <u>M</u> ade <u>S</u> ample
VISAR	<u>V</u> elocity <u>I</u> nterferometer <u>S</u> ystem for <u>A</u> ny <u>R</u> eflector
VST	<u>V</u> ariable <u>S</u> pring <u>T</u> ester
WR	<u>W</u> ar <u>R</u> eserve

MC4523 Sealed Cap

Component & Characteristics Development Report

INTRODUCTION

The MC4523 Sealed Cap is a hermetically sealed percussion primer assembly that provides ignition of the MC2736A Thermal Battery when the primer is struck with the appropriate mechanical stimulus. The MC2736A Battery is used on the W78 JTA, and the stimulus is a 2.2 gram steel firing pin traveling at a velocity of 398 inches/second. The tip of the firing pin has a spherical radius of 0.020 inch. The previous battery design (the MC2736) used the same percussion primer as in the MC4523 (the WW42C1 procured from Winchester) for ignition, however, it was not hermetically sealed. Qualified primers were furnished by Department 1552 through the former Mound facility and installation in the battery was the responsibility of the Battery Department (1522). The primer installation occurred at either the former Pinellas facility or at Eagle Picher Corp. and was the last step in battery fabrication. A sketch of the primer installed in the MC2736 Battery is shown in Figure 1.

Figure 1. Installation of the WW42C1 Primer in the MC2736 Battery.

Hermeticity of the MC2736 was desirable, but was not a design requirement and not measured. Although not a requirement nor specified on the drawings, a coating of glyptol (a common electronic sealant) was usually applied to the circular recess between the primer and the battery housing. The failure rate of the percussion primer in the MC2736, about five failures over the past ten years, was unacceptable. Causes of the failures were

identified as being glyptol contamination in the primer ignition mix, off center striking of the primer during testing, and faulty primer installation. Clearly, the primer installation process was not specified nor formally controlled. In 1992, in anticipation of additional requirements for future WR programs, it was decided to redesign the MC2736 Battery. It utilized a calcium anode, a calcium chromate cathode, and a lithium fluoride/potassium fluoride electrolyte. The new MC2636A battery uses a lithium-silicon anode, an iron disulfide cathode, and a lithium chloride/lithium bromide/lithium fluoride electrolyte. The primary motivation for the redesign was to remove the carcinogenic calcium chromate from the battery. The new battery requires hermeticity before, during, and after function. In the course of that redesign activity, the Battery Development Department (1522) and the Explosive Subsystems Department (1552) jointly agreed to improve the primer installation procedures.

Prior to the MC4523 activity, Reuben Weinmaster (now retired) had developed a G16 Percussion Primer Plate (PN387545) that made use of the G16 Primer. The primer and a titanium/potassium perchlorate booster charge were enclosed in a stainless steel cylinder, with a thin closure disk that was welded over the primer. The G16 Primer Plate was supplied to the Battery Department as a fully qualified part in terms of ignition sensitivity and hermeticity. The Battery Department's only task was to weld the Primer Plate to the case of the MC3246A Thermal Battery. Between 1990 and 1992, a replacement for the G16 Primer Plate was developed by the author. That component was the MC4282 Precision Percussion Primer. It was much like the G16 Primer Plate, except that a prefabricated primer was not used. A thorough discussion of the G16 Primer Plate, the MC4282, a review of past percussion primer performance, and an improved testing procedure have previously been reported.¹ The same design philosophy was used for the MC4523 Sealed Cap. The Battery Department would receive a prequalified primer assembly and would not be responsible for the pressing of the primer into the cavity, nor responsible for the hermeticity of the unit. A sketch of the finished battery case of the MC2736A is shown on Figure 2.

Figure 2. MC4523 Sealed Cap shown installed in the MC2736A Battery Case

The weld of the MC4523 to the battery case occurs early in the battery fabrication. This is a desirable feature since Department 1522 is now free to perform subassembly testing (ignition and hermeticity) on a relatively inexpensive part. Also, the hermeticity checking of the Battery Case to the MC4523 can be performed with the differential leak check technique as opposed to the bombardment technique on a completed Battery. The differential technique is at least 100 times more sensitive. Besides these cost effective and improved leak checking attributes, the MC4523 design provides a clearly defined administrative boundary of responsibility between Departments 1552 and 1522.

METHODOLOGY

The MC4523 Project has spanned the time frame of 1992 to the present. In that time frame, the DOE complex was reconfigured with transfer of production activities from previous production agencies (such as Mound) to SNL. A major consequence was the birth and ongoing maturation of the MDE project. MDE Projects are conducted with Concurrent Engineering through Process Realization Teams (PRT). The quality control requirements are governed by EP401418 instead of the former QC1 and QC2 documents. The MC4523 was one of the MDE Projects.

Process Realization Team

The first contract (AP-0369) was for MC4523 production and included the PPI, TMS, WR1, and WR2 lots. The contract was awarded to EG&G/Star City, Inc., (SCI) on a competitive bid process between three interested suppliers. Two other suppliers elected not to respond to the bidding process. The PRT for the MC4523 Sealed Cap is shown in Table 1 below.

Table 1. The PRT for the MC4523 Sealed Cap.

*David R. Begeal	SNL 01512	Design/Production Engineer
*Guy E. Dahms	SNL 12336	Quality Engineer
Craig Amundson	SNL 10251	SCR
*Daniel Knick	SCI	Senior Test Engineer
*Julie A. Thomes	SCI	Quality Engineer
Robert Tomasowski	SCI	Production Engineer
John Adams	SCI	Process Engineer
* denotes the core PRT representatives		

One of the most significant outcomes of the PRT business practice was that the supplier is a fully empowered member of the PRT. The MC4523 was manufactured per formal SNL drawings that are released through the Image Management System (IMS) and furnished to the supplier. Manufacturing procedures, processes, tooling, test equipment, etc., are formally documented in the suppliers drawing system. Changes to the drawings (both SNL's and the supplier's) required PRT consensus before they were carried out. A requirement of EP401418 is that appropriate Qualification Engineering Releases (QERs) be released prior to submittal of WR product. The manufacturing and testing equipment and processes were rigorously examined during the Engineering Qualification (EQ) activity in order to grant the QERs. The EQs were conducted during the PPI and TMS phases of the project. The QERs were released at the acceptable status prior to submittal of WR product for acceptance.

Drawings and Engineering Release History

The SNL drawing set for the MC4523 is described in Table 2 below. The associated Engineering Releases, SXR, and specifications are included. The letters A, B, C, etc., refer to the issue of the drawing. The drawings are available through IMS.

Table 2. MC4523 Drawing Set and Engineering Release History

DRAWING NUMBER	TITLE	ENGINEERING RELEASE	950647SA CER 02/14/96	951001SA AER 03/20/96	951020SA FCO 03/12/96	960330SA ACO 03/18/96	960172SA CER 04/26/96	960241SA ACO 04/24/96	960242SA ACO 03/29/96	960870SA ACO 07/25/96	961016SA REV 1 ACO 09/23/96
PX413691	PRODUCT INDEX		A							B	C
PS413691	PRODUCT SPEC		A		B				C		D
413691	MC4436 SEALED CAP		A	B				C			D
AY378974	PRIMER		C	D							
378974	PRIMER					C					
399050	BODY		A	B				C			D
399051	DISK		A	B				C			
706299	HOLDER		A	B				C			
706482	TEST ASSEMBLY		A	B				C			
706469	VARIABLE SPRING TESTER						A				
AM706469	SOFTWARE DOCUMENT						A				
AF706469	OPERATING PROCEDURE						A				
SD706496	SOFTWARE (disk)						A				
9912700 Iss A	WELDING										
9956010 Iss R	DIFFERENTIAL LEAK CK										
960002SA	PRODUCTION EQ PLAN		EER	1/2/96							
960001SA	MC4523 STAGE 1 EQ		QER	4/16/96		ACCEPTABLE					
960003SA	VST EQ PLAN		EER	1/2/96							
960475SA	TESTER (VST)		QER	4/16/96		ACCEPTABLE					
961126SA	413691		SIER	9/23/96		B-ITEM DECLARATION					
N0033SA96SA			SXR	May-96		TEST SAMPLES ON LOTS 1&2					

Lot Records

The process for developing and maintaining lot records is described in detail in the Product Specification (PS413691). The records comprise three separate manuals as follows:

Process Manual: This is a compilation of the SNL drawings, SCI drawings, and the SCI procedures to perform all manufacturing operations. Blank data forms are also included. In general, this manual should be the same from lot-to-lot, and only requires updates for subsequent lots as drawings are changed. All drawings (SNL and SCI) require formal change paper to be modified. This manual alone should describe how the component was manufactured.

Lot Record Supporting Data: This is a compilation of all the quality control data (material certifications, inspection reports, etc.) and other supporting data that certify the completion of all required process steps during manufacture and testing. For example, this manual contains the environmental conditioning records for the D-Test sample and the temperature charts that verify drying prior to packaging.

Lot Record Summary Manual: This manual is a summary of the lot and includes a serial number listing, yield and rejects, the completed data forms for the record of assembly and lot acceptance tests, a certificate of compliance, a table of calibrated equipment used, and the forms used for SNL and/or DOE acceptance.

The originals of these three manuals were submitted to the Recorded Information Management Department (15102) for archival. Only the Lot Record Summary Manual was submitted to IMS for maintenance as an electronic copy. In addition, one set of copies of the three manuals are maintained at the supplier, and one copy of the Lot Record Summary Manual was submitted to the SNL Product Engineer. These manuals have been delivered for WR Lots 1 and 2.

DESIGN AND MANUFACTURING

General

As shown in Figures 1 and 2, the MC4523 Sealed Cap is a WW42C1 Primer that is pressed into a steel cylinder, and covered with a thin steel closure disk for hermeticity at the input end. Figure 3 shows the MC4523 Sealed Cap and the dimensions of the component.

PA101 Ignition Mix	wt%
Basic Lead Styphnate	53
Tetracene	5
Barium Nitrate	22
Antimony Sulfide	10
Aluminum Powder	10

TOTAL = 22 mg

Figure 3. Detail of the MC4523 Sealed Cap

The WW42C1 Primer.

The core of the MC4523 design is the WW42C1 primer. This is a common pistol primer that can be purchased from local public sources such as sporting goods stores. They are manufactured by Western Winchester (hence the WW) in large volumes and have been found to have high reliability if properly installed and fired to the manufacturers recommended specifications. As shown in Figure 3, the WW42C1 uses a copper cup and brass anvil construction. The PA101 ignition mix is loaded as a wet slurry. The ignition mix is retained in the copper cup with a paper disk and the anvil. After drying, a coating of shellac is applied to the open end of the primer. The composition of the PA101 ignition mix is shown in Figure 3. The brass anvil shown in Figure 3 actually has three equally spaced legs, however, in Figure 3, one leg is shown rotated for visual clarity. The shellac coating is not shown.

In January 1986, Mound procured 100,000 WW42C1 primers from Winchester at a cost of \$3800. The Winchester drawing of the primer (as received) allows a total height of 0.115 +/- 0.004 inch. In an effort to improve the quality of the final primer configuration, SNL and MD elected to tighten the tolerance to +/- 0.001 inch. Mound performed a robotic dimensional screening operation to select the primers with the tighter tolerance. The yield from the screening was approximately 30,000, which were placed in MD bonded stores. Since DOE complex reconfiguration, the 30,000 screened WR primers have been transferred to the SNL bonded stores for WR use. Three thousand of the WR primers were furnished to SCI for use on contract AP-0369. Approximately 20,000 of the screened rejects are still owned by SNL and are used for various development activities.

Primer Installation

A design requirement of the MC2736A Battery was that the external geometry of the MC2736 be maintained. Figures 1 & 2 shows that to be the case. A key factor for repeatable ignition sensitivity is that there is no gap between the primer copper cup and the 0.005 inch thick closure disk. This interface was reliably produced by the manufacturing process and the associated tooling. A dimensional analysis shows an interference fit of about 0.001 inches between the primer outer diameter and the inner diameter of the cavity in the Body. The diameter mismatch is intentional so that there is a pressed fit. Also, the primer height is shortened by an average of 0.004 inches when installed due to a powder recompaction procedure that is recommended by the manufacturer, Winchester. It is doubtful that the powder is truly "recompacted" between the anvil tip and the copper cup, however, the amount, (or height) of material that is pinched upon firing pin impact is certainly less, which should improve ignition sensitivity. By using the primers with the tighter tolerances on the overall height, this recompaction procedure results in a more uniform design.

The tooling used to install the primer into the Body is described in the Process Manual. In brief, the tooling assured straight primer installation, and that the primer was pressed to nearly flush into the Body. There was always some amount of spring back of the copper

cup when the primer was pressed into the Body cavity. This amount of spring back varied depending on the degree of the interference fit, and on the shape, thickness, and hardness of the copper cup. This small amount of copper cup protrusion was removed by manually grinding the assembly with fine grit sand paper mounted on a flat plate until there was visual evidence of no more copper removal. This processing method and the USE of the screened primers provided the least number of variables at the primer to closure disk interface.

Welding

Two welds are used on the MC4523. The first is the weld of the closure disk over the flush primer, and the second is the weld of the Sealed Cap to the Battery Case, or in lot acceptance testing, to the test device. In either case, it is essential that the primer mix not get too hot during the welding process. Kinetic data for the degradation of the PA101 primer mix is not available, however, it is advisable to keep the temperature of the mix below 100°C during the short times that are expended during welding. Temperature above 120°C can lead to decomposition of the tetracine in the PA101 ignition mixture. Tetracine is essential to providing the ignition sensitivity of the WW42C1 Primer. Temperature above 160°C can result in autoignition of the WW42C1 Primer. In preliminary weld studies at SNL in 1992, it was found that there was little margin between igniting the primer and making a good closure weld. Test samples to monitor the temperature in the region of the ignition mix were prepared by welding a thermocouple to the inside surface of the Body approximately 0.030 inches from the top surface. A sketch of this setup is shown in the Appendix, Figure A 5. The temperatures measured with the thermocouple in this location are probably conservative. That is, the copper cup and ignition mix are additional heat sinks which would most likely lower the actual powder temperature, however this assumption was not confirmed. During the development work at SNL, the thermocouple temperature during a "normal closure disk weld" was approximately 160 °C. The early design used closure disks that were 0.250 inches in diameter, and the closure disk rested in a counterbore in the Body.

At SCI, the weld fixturing provided more heat sinking, the closure disk was a larger diameter (.276 inches) to move the weld joint further away from the primer, and the disk is not in a counterbore. The net result was less heat transferred to the ignition mix during welding. The tooling used while making the closure disk to Body weld assured that the disk remains flat on the Body surface. The weld schedules, photographs of the weld sections for the closure disk weld and the test assembly weld, and associated thermal records are shown in the Appendix, Figures A1 through A5. For the closure disk weld, the laser power was 16 +/- 2 watts. Note that the thermocouple record at 18 watts showed a repeatable maximum temperature of 85 °C. The test assembly weld uses a laser power setting of 30 +/- 2 watts. At 32 watts, the temperature was also 85 °C. When 40 watts of laser power was applied, 100 °C was exceeded for a short period of time. Note that both production welds show excellent weld penetration.

Inspection Processes

Other than dimensional inspection of the piece parts, there are relatively few inspection steps for the Sealed Cap. The height of the primers was reverified to meet the 0.115 +/- 0.001 inch dimension on all primers. At the same time, the inside of the primer was examined for any obvious abnormalities. After the grinding step described above, the location of the copper cup relative to the Body was verified to be within a tolerance is +/- 0.0002 inches. The grinding and inspection steps were the most significant improvements over past installation procedures.

One advantage of using the Sealed Cap approach, was the possibility of obtaining x-ray inspections of the MC4523 with much more resolution than was possible with the primer directly installed in the battery. The increased resolution was thought possible because the MC4523 could lay directly on the x-ray film, whereas in the MC2736 Battery configuration, the primer was displaced from the film by the battery radius. Development lots of the MC4523 were x-rayed, and the gap between the closure disk and primer, as well as the straightness of the primer in the cavity of the body were examined. Records of the x-rays are not reproduced here, however, gaps between the primer and closure disk were observed that were as great as 0.005 inches as measured with an optical comparator on the x-ray film. No misalignment difficulties were observed, even though the installation tooling used at that time was modified commercial munitions hand loading equipment.

The x-ray inspection technique was used on the PPI and TMS lots of the MC4523 that were fabricated at SCI. No gaps were observed at the closure disk/copper cup interface. Quality comparison samples with known gaps of 0.0025 and 0.005 inches were purposely fabricated during the TMS Lot. X-rays of these samples showed that the x-ray inspection could not differentiate between samples with a 0.0025 inch gap and samples with a zero gap. The gap on the x-ray film from the 0.005 inch gap quality comparison sample was visible, but could not be accurately measured. In retrospect, the gaps on the development units were probably larger than measured. It was felt that the absence of gaps at this interface could not be assured by the x-ray inspection, but was assured by the new manufacturing processes and inspections, therefore the x-ray inspection was deleted from the processing requirements. The all-fire test results from the subsequent WR Lots bolster the validity of this decision.

TEST RESULTS

Test Procedure

The MC2736A Thermal Battery is actuated by mechanical firing pin impact from the MC1996 Actuator. This actuator accelerates a 2.2 gram steel firing pin (with a tip radius of 0.020 inch) at a velocity of 398 inch/second. This velocity was measured in 1989 with a VISAR system by the Explosive Diagnostics Division (now Dept. 1554). This value was the result of 5 consecutive measurements that showed a repeatability of about 1%. The lowest value measured was 398 inch per second. The all-fire level that the primer must achieve has been defined as 398 in/s for this firing pin, or 112 mJ when defined in terms of mechanical energy. In this discussion, all-fire is defined as the probability that 999 of 1000 units will fire with a confidence level of 50% when given the minimum stimulus of 112 mJ. Conversely, no more than 1 out of 1000 will not fire. Previously, the tester used to determine the all-fire sensitivity of percussion primers was of the "ball drop" variety where a ball of a known weight strikes a firing pin that is at rest on the primer. By knowing the drop height and ball mass, and assuming perfect momentum transfer through the firing pin, the impact energy was readily calculated. It is important to recognize that primer ignition sensitivity is not strictly dependent on the energy of the impact stimulus, but is also affected by the firing pin velocity. These results were found during the previous extensive study.¹

Based on that study, it was decided that the MC4523 project would use the more realistic method of testing that is offered with the Variable Spring Tester (VST). The VST is also described in Reference 1. Two test methods for lot acceptance were used. The all-fire sensitivity was determined by using the Neyer² test method. The sample for each Neyer sequence was 25 units. The second test method (hard fires) used a sample of 25 units that were fired just below the all-fire level (110 mJ). The hard fire tests were conducted at the cold STS temperature, and the units were fired into a small sealed chamber so that the pressure generated by the primer could be measured. At present the pressure data is for information only. The hard fire requirement was that all tested units must fire. Some of the test groups received no environmental conditioning prior to testing (labeled CTR). Otherwise, the test group received environmental conditioning (ENV) prior to testing. This environmental exposure was a sequence of thermal shock exposures followed by vibration and mechanical shock testing. The levels of these exposures are given in the Product Specification (PS413691).

The Variable Spring Tester used by SCI was the same tester that was used during the development of the MC4282 Precision Percussion Primer.¹ The only difference was that the VST had changed locations (Phoenix to Dayton) and had undergone the necessary EQ activities described earlier. Regardless, comparisons of data from development through WR production are valid. That is, all development data used QC2 as the guideline for data certification, and the accuracy was not in question. What is lacking for the development data are retrievable calibration records that certify the equipment accuracy.

Lot Acceptance Data

Table 1 is a compilation of the test results that have been obtained for the MC4523 Sealed Cap. Early development data and the most recent WW42C1 primer data are included in Table 1 for comparison. All of the data in Table 1 were obtained with the VST using a 2.2 gram firing pin that had a 0.020 inch hemispherical radius tip. It was noted at the end of the Lot 2 testing that there was some flattening of the radius tip. It is doubtful that this has any effect on the results since the pinch point of the powder is at the tip of the brass anvil. The 0.02 inch protrusion of the tip is probably more important, and at the end of the Lot 2 testing, it still protruded 0.018 inch.

One factor that prevented direct comparison of all the data is that the development work in 1992 and 1993 used the primers that were rejected at the height screening step. Note that the all-fire results were very close to the requirement of being less than 112 mJ. It is expected that the presence of the closure disk adds about 20 mJ to the ignition sensitivity. Controlled processing at the supplier and use of the screened primers significantly lowered the ignition sensitivity. It is not known which factor was the cause of the improvement. Most likely, the improvement was due to a combination of both. Regardless, the sensitivity test data for the SCI manufactured Sealed Caps are excellent.

It should be noted that the Neyer all-fire test data, for small sample sizes like 25 units, only provides an indication of all-fire. For the seven runs at SCI (PPI through Lot 2), the variability in sigma and threshold (average) is typical. Confidence in the accuracy of the results increases as the sample size becomes larger. By assuming that there was no affect between ENV and CTR units (and there shouldn't have been), the seven runs were combined to give the average all-fire result of 66.8 mJ shown in Table 3. Note that threshold testing does not prove reliability, but does support meeting the requirement. The accumulation of hard fire test data is what eventually provides proof of meeting the reliability requirement. At present, 100 tests have been conducted with no failures. That number of tests prove a reliability of .993 at 50% confidence, but more importantly, there is no evidence to show that the .999 requirement cannot be met.

Table 3. MC4523 Lot Acceptance Test Results.

ALL FIRE RESULTS	DATE	AVERAGE (mJ)	SIGMA (mJ)	ALL-FIRE (mJ)(.999@50%)
Bare WW42C1 Primer *	Jun-92	40.6	2.5	50.1
SNL CONCEPTUAL *	Jun-92	68.7	10.4	113.9
SNL PROTOTYPE *	Sep-93	59.9	11.1	94.1
PPI (CTR group @ AMB)	Feb-96	40.7	5.5	57.6
TMS (CTR group @ AMB)	Mar-96	40.4	5.7	57.9
TMS (ENV group @ AMB)	Mar-96	40.6	12.3	78.7
LOT 1 (CTR group @ AMB)	Apr-96	36.5	4.6	54.7
LOT 1 (ENV group @ AMB)	Apr-96	34.5	4.9	54.0
LOT 2 (CTR group @ AMB)	Jul-96	35.6	7.0	64.9
LOT 2 (ENV group @ AMB)	Jul-96	43.1	4.7	62.2
Pooled 1996 Data **		38.6	8.2	66.8

* These primers were the screened rejects that were used in development. See Reference 1 for the more complete discussion on the bare primer results.

**Combined data for a single ASENT Analysis.

PRESSURE PULSE RESULTS	AVERAGE	SIGMA
25 tests per group	(PSI)	(PSI)
PPI (CTR group @ AMB)	1450	160
TMS (ENV group @ -40°C)	1678	174
LOT 1 (ENV group @ -40°C)	2012	206
LOT 2 (ENV group @ -40°C)	1852	214

CONCLUSIONS

This report has described the MC4523 Sealed Cap and reported the results through two WR production lots at a commercial supplier. There were no rejects in the manufacture of 615 units, and only one closure disk weld required rewelding. The lot acceptance test results show an all-fire of approximately 67 mJ of mechanical energy for a 2.2 gram firing pin with a firing tip that has a 0.02 inch hemispherical radius. This is well below the all-fire requirement of 112 mJ. Environmental conditioning of the units showed no effect on the test results.

Production of the MC4523 occurred at a new commercial supplier, It is an MDE component with SNL as the production agency. Development of the infrastructure required to successfully produce this component was found to be smooth. One SXR was required to accept product, and the final drawings were up to Issue C. The SXR was to allow the preferential use of cosmetic rejects (due to marking) in the D-Test sample. The most significant factor that allowed achievement of this performance was the planning and execution of the separate PPI and TMS phases of the project. In contrast, another component was undergoing production at the same supplier in the same time frame (the MC4436). There was neither budget or schedule resources to allow these separate phases. In this case, there were 4 SXRs, and several of the drawings had been through ten issue changes prior to SNL source acceptance of product. The contrast is a clear indication on the necessity of performing separate PPI & TMS phases of a project.

The lessons learned on the MC4523 Project are two fold. First; the ability to conduct separate PPI and TMS is desirable. Secondly, the use of closely controlled processes and rigorous inspections showed a marked improvement in the quality of the final product.

REFERENCES

1. Begeal, D. R., *A High Temperature Hermetic Primer and A Variable Spring Tester*, SAND94-0192, May, 1994. Also see the Proceedings of the Twentieth International Pyrotechnics Seminar, page 107, July, 1994, Colorado Springs, CO.
2. Neyer, Barry T., *"More Efficient Sensitivity Testing"*, MLM-3609, October 20, 1989

APPENDIX

FIGURE A 1 WELD SCHEDULE FOR THE MC4523 CLOSURE DISK WELD.....	22
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Subassembly Drawing No. 413691

Material Combination 304L to 304L

Welding System No. 1

Fixture Drawing No. See No. 2 below

Welding Specification No. N/A

Welding System Location Building 49

WELDING SCHEDULE PARAMETERS

<p>PFN Configuration <u>1 capacitor and 1 inductor in the top four banks</u></p> <p>Objective Lens Focal Distance <u>4.0 inches</u></p> <p>Work-To-Objective Lens Reference Distance <u>4.005 ±.005</u></p> <p>Intracavity Aperture Size <u>None</u></p> <p>Range Multiplier <u>X 10</u></p> <p>Pulse Mode <u>Repetitive</u></p> <p>Energy/Pulse (Dial Setting) <u>600</u></p> <p>Transport Shutter <u>Closed</u></p> <p>Tap <u>High</u> Charging Inductor <u>140</u></p> <p>Pulse Rate Counter <u>20</u> PPS</p> <p>Rotary Optics: <u>N/A</u></p> <p>Speed of Rotation Circle Size <u>N/A</u> SEC/REV <u>N/A</u> IN. ϕ</p> <p>Shielding Gas: <u>Argon</u></p> <p>Gas Flow Rate: Nozzle <u>35</u> CFH Shield <u>30</u> CFH</p>	<p>SHUTTER/TIMER CONTROL:</p> <p>MODE <u>Timed</u></p> <p>SHUTTER TIME <u>7.6 sec.</u></p> <p>WELD OR PROCESS TIME <u>6.1 sec.</u></p> <p>RAMP TIME <u>N/A</u></p> <p>POST RAMP TIME <u>N/A</u></p> <p>SLOPE ADJUSTMENT <u>300 (range 2)</u></p> <p>SHOTS/SEC <u>N/A</u></p> <p>LASER BEAM POWER <u>16.0 ±2</u> WATTS</p> <p>POWER METER RANGE <u>100</u></p> <p>ZERO POWER LIMITS-LOW <u>-0010</u>, HIGH <u>+0010</u></p> <p>WELD POWER LIMITS-LOW <u>0140</u> HIGH <u>0180</u></p>
<p>Special Techniques/Comments:</p> <ol style="list-style-type: none">1. Reference distance adjusted by setting distance from bottom of lens holder to top of part.2. Fixture drawings: 324100, AYC910144, AND AYE7703673. Unidex indexer set at 32400.4. Speed of part is 6.1 sec/rev.5. Switch on rear of laser transport console set on "set up".6. Use 1.50 in. Brass legs to bring fixture in focus.7. Crosshair placement 0.002 in. on to disk.	

Figure A 1 Weld schedule for the MC4523 closure disk weld

This schedule is the actual form used by SCI, and is their document number WS1014, Issue 1.

Figure A 2 Photographs of closure disk weld cross sections

The magnification is 145 X.

Subassembly Drawing No. 706482
Welding System No. 1
Welding Specification No. N/A

Material Combination 304L to 304L
Fixture Drawing No. See No. 2 below
Welding System Location Building 49

WELDING SCHEDULE PARAMETERS

<p>PFN Configuration <u>1 capacitor and 1 inductor in the top four banks</u></p> <p>Objective Lens Focal Distance <u>4.0</u> inches</p> <p>Work-To-Objective Lens Holder Reference Distance <u>4.005 ± .005</u></p> <p>Intracavity Aperture Size <u>None</u></p> <p>Range Multiplier <u>X 10</u></p> <p>Pulse Mode <u>Repetitive</u></p> <p>Energy/Pulse (Dial Setting) <u>600</u></p> <p>Transport Shutter <u>Closed</u></p> <p>Tap <u>High</u> Charging Inductor <u>140</u></p> <p>Pulse Rate Counter <u>20</u> PPS</p> <p>Rotary Optics: <u>N/A</u></p> <p>Speed of Rotation Circle Size <u>N/A</u> SEC/REV <u>N/A</u> IN. ϕ</p> <p>Shielding Gas: <u>Argon</u></p> <p>Gas Flow Rate: Nozzle <u>35</u> CFH Shield <u>30</u> CFH</p>	<p>SHUTTER/TIMER CONTROL:</p> <p>MODE <u>Timed</u></p> <p>SHUTTER TIME <u>7.3 sec.</u></p> <p>WELD OR PROCESS TIME <u>5.90 sec.</u></p> <p>RAMP TIME <u>N/A</u></p> <p>POST RAMP TIME <u>N/A</u></p> <p>SLOPE ADJUSTMENT <u>300 (range 2)</u></p> <p>SHOTS/SEC <u>N/A</u></p> <p>LASER BEAM POWER <u>30 ±2</u> WATTS</p> <p>POWER METER RANGE <u>100</u></p> <p>ZERO POWER LIMITS-LOW <u>-0010</u>, HIGH <u>+0010</u></p> <p>WELD POWER LIMITS-LOW <u>0280</u> HIGH <u>0320</u></p>
<p>Special Techniques/Comments:</p> <ol style="list-style-type: none">1. Fixture drawings: 324101 AND AYE7703672. Unidex indexer set at 32400.3. Speed of part is 5.8 sec/rev.4. Switch on rear of laser transport console set on "set up".5. Crosshair should be 0.004" ±0.001" on Cap Holder.6. Ensure crosshair placement is on sample spot weld.7. Ensure concentric alignment of crosshair with respect to edge of disk.8. Use 1.50 in. Brass legs to bring fixture in focus.	

Figure A 3 Weld schedule for the MC4523 next assembly weld

This schedule is the actual form used by SCI, and is their document number WS1015, Issue 1.

Figure A 4 Photographs of the Test Assembly weld.

The magnification is 140 X.

Figure A 5 Thermocouple records during welds.

These charts are reduced reproductions of the actual strip charts. The temperature scale (x) is from 0 to 100°C or 20°C per major division. The time scale is 8 inches/minute where one minute is a major division. This equates to 0.75 seconds per minor division. The sketch in the lower left corner shows the approximate thermocouple location.

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