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**Modification Of Toolmakers' Microscope
For Use In An Explosive Environment**

Charles F. Draut

December 30, 1975

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Research and Development Report

MOUND LABORATORY

Miamisburg, Ohio
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Abstract

A large Leitz Universal Toolmakers' Microscope, Model UWM, was modified for use in an explosive environment defined by the National Electric Code as a rating of Class II, Group G. Use of the explosion-proof (EP) microscope provided a means for dimensionally measuring delicate pressed explosive material without contacting the material and subjecting it to possible contamination and mechanical destruction. Inexpensive design concepts, material, and hardware were used to effect the modifications of explosion-proofing. The accuracy, sensitivity, and repeatability of the Toolmakers' Microscope were not altered by the modification.

Introduction

The need for a noncontact method of dimensionally measuring delicate pressed explosive materials, in explosive environments, without destroying and/or contaminating them has existed for some time at Mound Laboratory.

Previous methods for the measurement of these delicate pressed materials relied on ultracareful handling and operation of mechanical gaging equipment in open setup which did not completely accomplish either of the objectives of noncontamination nor of dimensional nondestruction of the delicate material. The measurement of delicate pressed explosive materials with mechanical gaging equipment in open setup is an extremely slow and tedious operation. An optical comparator was also used to some extent to accomplish nondestructive and noncontaminating measuring, but the results were nondefinitive.

Some of the design criteria that were established as a base for development of a method of measuring delicate explosive items were as follows:

- The system is to be explosion-proofed for use in hazardous locations as defined by the General Safety Section at Mound Laboratory, and to conform to the criteria of the National Electric Code.
- The system is to be noncontacting, if feasible.
- The basic measuring system should be readily available on the open market.
- Any modifications to the basic system should be relatively inexpensive and easily accomplished.
- Any modifications should not alter the accuracy, sensitivity, or repeatability of the system.

After a literature search for methods of measuring delicate or fragile materials in hazardous locations was concluded, a decision was made to modify a toolmakers' microscope for these applications. This report is directed to that modification process performed on a Leitz Universal Toolmakers' Microscope, Model UWM. The operation of the microscope is described in Appendix A.

Hazardous Environments

Article 500 of the National Electrical Code (NEC)¹ separates hazardous locations and/or environments into Class I, II, and III. In each class,

the National Electrical Code recognized a Division 1 location where hazardous atmospheric concentrations can exist under normal operating conditions, and Division 2 where, in general, such hazardous conditions can exist only infrequently through an accident or an abnormal situation.

The Army Materiel Command Safety Manual, AMCR 385-224, which deals primarily with explosives does not consider that the NEC Division 2 requirements provide adequate protection; it classifies areas as either Division 1 or nonhazardous.

- Class I Locations - Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Electrical equipment for a Class I, Division 1, location is designed and fabricated so that the electrical enclosure can resist an internal explosion or can confine the burning mixture within the enclosure without propagating to the outside.

- Class II Locations - Class II locations are those which are hazardous because of the presence of combustible dust. These locations are subdivided into three groups as follows: Group E, atmospheres containing metal dust; Group F, atmospheres containing carbon black, coal dust, or coke dust; and Group G, atmospheres containing flour, starch, or grain dusts. Equipment for Class II, Division 1, locations is designated dust-ignition-proof. Such equipment is designed so that ignitable amounts of dust cannot get into it, and so that arcs, sparks, or heat generated inside the electrical enclosure cannot ignite exterior accumulations or atmospheric suspensions.²

- Class III Locations - Class III locations are those which are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures.

The explosives commonly used in detonator and timer manufacturing are PETN, 9007 and 9407 PBX, and tetryl and are classified as secondary explosives. The General Safety Section at Mound Laboratory designated the manufacturing locations in which the aforementioned explosives are used as Class II, Group G, hazardous locations or environments.

Electrical equipment which is approved for use in Class I hazardous locations is also approved for use in Class II, Group G, applications at Mound Laboratory. The Mound dust-ignition-proof (EP) standard, however, does not apply to Class I locations.

Methods to Effect Dust-Ignition-Proof Equipment

Listed below are a portion of the approved methods for making electrical equipment acceptable as "explosion proof" or "dust-ignition-proof" according to Mound Laboratory standards³ established by the General Safety Section:

1. Remove all electrical items that can cause an arc or spark such as switches, relays, receptacles, pushbutton stations, motor starters, and circuit breakers and mount these items in an approved enclosure for hazardous locations and/or remotely locate them in a nonhazardous environment.

2. Remove from the equipment all items capable of producing "hot spots" (heated surfaces) such as motors and lighting fixtures, and items that are breakable and exploding such as amplifiers, filament lamp bulbs, and electronic tubes. Electrical components of this type should be relocated in approved enclosures for hazardous locations and/or remotely located in a nonhazardous environment. Consideration should be given to the fact that wiring (especially splices), transformers, impedance coils, solenoids, and other low-temperature equipment without contacts could become sources of ignition if their insulation were to fail.

3. Equipment not available or unable to conform with items 1 or 2 above shall meet the following minimum requirements before they will be approved as "explosion proof" equipment.

- The item or unit shall be encased in an enclosure made of 1/4 in. (minimum thickness) Plexiglas SE-3 or a material of equal integrity.
- All crevices and joints shall be sealed with a suitable epoxy resin or glue.
- All access doors and openings shall be kept to a minimum and a soft rubber gasket used to ensure a positive seal whenever an opening is required.
- A micro-switch shall be installed on all access doors and openings to shut down the main power supply to the unit when the doors or closures are opened and/or not properly secured.
- The enclosure shall have a constant air purge. A bubbler or flow indicator shall be provided in the air purge line or a differential pressure gage (Magnehelic) installed on the enclosure to provide a definite indication that the enclosure is being constantly purged (pressurized).
- A differential pressure switch shall be installed in the enclosure so that the power supply to the internal components is automatically turned off when the air purge pressure drops below a predetermined level.
- A pressure relief valve or hinged flapper shall be installed on all enclosures to prevent an excessive pressure buildup inside the enclosure.
- All power cords and cables entering or leaving enclosures shall be placed through a Crouse-Hinds CGB connector or an equivalent connector complete with a gland nut and watertight neoprene bushing.
- All cords and cables shall be Underwriters' Laboratory approved.

Modifications Required to EP Equipment

An ancillary storage cabinet, on which the toolmakers' microscope was mounted, housed the 110-V power supply input, transformer, switches, a potentiometer, and six receptacles as shown in Figure 1. These receptacles

FIGURE 1 - Modified EP Toolmaker's Microscope System and ancillary storage cabinet.

provide power for the filament lamps for transmitted light (12 V, 60 W), scale illumination (6 V, 15 W), and the graduated circle in the binocular measuring tube (8 V, 5 W). The power for the incident-light illumination for the binocular measuring tube (8 V, 5 W), monocular measuring tube (8 V, 5 W), and the X-Y stage (8 V, 5 W) was also obtained via the same grouping of receptacles.

An explosion-proof junction box (Killark, Series DB) was procured and modified to serve as the control box for the modified EP Toolmakers' Microscope system. The 110-V power input was supplied to the control box via Underwriters' Laboratories (UL) approved Securityflex, three-conductor cord through a Crouse-Hinds CGB straight connector complete with gland nut and watertight neoprene bushing. The transformer with tapped secondary from 115 V to 6, 8, 10, and 12 V was removed from the original storage cabinet and mounted inside the EP control box. Toggle switches, five-position rotary switch (0-6-8-10-12 V), and potentiometer (which were mounted on the original storage cabinet) were no longer used.

The aforementioned service was moved to the control box and replaced by Killark (EP) standard snap-switch assemblies, a standard, maintained-contact, selector-switch assembly, and a potentiometer operator. A wiring diagram of the control box is shown in the Appendix B. The open female electrical receptacles were replaced by military specification, MIL-C-5015, approved Amphenol wall-mounting, pressurized receptacles mounted in the bottom of the control box (Figures 1 and 2). An Amphenol cap and chain assembly was provided to cover each receptacle, when not in use, to keep airborne dust from settling in the receptacles. The caps had soft rubber discs which seat on the connector shells to form tight joints.

The filament lamps were of three varieties and/or configurations. The bulbs and sockets are shown in Figure 3; they were mounted in various lensed housings or open cavities which were vented for heat dissipation. The filament lamp bulbs were hazardous because they could produce "hot spots" (heated bulb surface) and because of the possibility of an exposed heated bulb filament if the glass broke or if the bulb exploded.

Special enclosures were designed for all filament lamp applications so that ignitable amounts of explosive powders (dust) could not get into them, and so that arcs, sparks, or heat generated inside the enclosures could not ignite exterior accumulations or atmospheric suspensions. The enclosures were fabricated with aluminum housings, which were finned or air purged to effect efficient heat dissipation, and threaded end caps to facilitate the insertion of the original bulb and socket assemblies inside the enclosures. The filament lamps and the enclosures were grounded with a ground tie connected to the ground conductor in the Securityflex, three-conductor cord. Entry of the cord to each enclosure was via a fitting (designed in one end cap to simulate a Crouse-Hinds CGB straight connector) complete with gland nut and watertight neoprene bushing. The special filament lamp enclosures are shown in Figures 4 through 8.

The cord of each lamp enclosure was connected to the explosion-proof control box (via a wall receptacle) by a matching MS straight plug connector (Figures 1 and 2).

FIGURE 2 - Military specification connectors and accessories.

FIGURE 3 - Original filament lamps and vented lensed housings.

FIGURE 4 - Incident light for illuminating X-Y stage for surface measurement.

FIGURE 5 - Incident light for illuminating reticule and angular scale of binocular head.

FIGURE 6 - Incident light for illuminating binocular and monocular measuring tubes, 1X and 5X magnifications.

FIGURE 7 - Filament lamp for scale illumination.

FIGURE 8 - Filament lamp for transmitted light.

Heated Surfaces Testing

Temperature testing and evaluation of the special filament lamp enclosures were done to determine whether any "hot spots" (heated surfaces) existed. The testing was conducted in the Mound Tooling Laboratory; the room ambient temperature was recorded as between 69-70°F. All enclosures were adequately scanned to determine where the "hot spots" were if any existed. The following general temperature values were recorded.

ENCLOSURE: Hanging incident lights for X-Y stage illumination (see Figure 4), 8 V

TEMPERATURE RANGE: 97-104°F

REMARKS: Normal ambient air cooling

ENCLOSURE: Incident light for binocular and monocular measuring tubes 1X (see Figure 6), 8 V

TEMPERATURE RANGE: 99-106°F

REMARKS: Normal ambient air cooling

ENCLOSURE: Incident light for binocular and monocular measuring tubes, 5X (see Figure 6), 8 V

TEMPERATURE RANGE: 87-91°F

REMARKS: Normal ambient air cooling

ENCLOSURE: Scale illumination light, 8 V (see Figure 7)

TEMPERATURE RANGE: 97-101°F

REMARKS: Normal ambient air cooling

ENCLOSURE: Scale illumination light, 8 V (see Figure 7)

TEMPERATURE RANGE: 85-88°F

REMARKS: 20 psi forced cooling air input through 0.25 in. diameter tubing

ENCLOSURE: Transmitted light, maximum setting at 15 V (see Figure 8)

TEMPERATURE RANGE: 118-127°F

REMARKS: Normal ambient air cooling

ENCLOSURE: Transmitted light, maximum setting at 15 V (see Figure 8)

TEMPERATURE RANGE: 95-106°F

REMARKS: 20 psi forced cooling air input

ENCLOSURE: Transmitted light, maximum setting at 15 V (see Figure 8)

TEMPERATURE RANGE: 95-101°F

REMARKS: 40 psi forced cooling air input

Even though the designed modifications included an air supply and pressure relief valves on the scale illumination and transmitted light lamp enclosures, no cooling air was ultimately used. The maximum "hot spot" recorded was 127°F on the transmitted light lamp enclosure, which is well below the melting and decomposition temperatures* of the explosives that could come into contact with the enclosure. For Class II environments in general, the maximum surface temperatures under actual operating conditions shall not exceed 165°C (329°F) for equipment which is not subject to overloading, and 120°C (248°F) for equipment such as motors or power transformers which may be overloaded.

Summary

A Leitz Toolmakers' Microscope, Model UWM, was modified and moved into the Explosive Environment Annex of the Mound Tooling Laboratory for dimensionally measuring delicate pressed explosive materials or products containing explosives materials. This laboratory area was designated as a Class II, Group G, hazardous environment by the General Safety Group at Mound Laboratory; the system was modified to meet this National Electric Code rating.

Special enclosures were fabricated for all filament lamp applications so that ignitable amounts of explosive powders could not get into them, and so that arcs, sparks, or heat generated inside the enclosures could not ignite exterior accumulations or atmospheric suspensions. The electrical controls of the microscope were removed from the original cabinet and repackaged in an explosion-proof junction box. The accuracy, sensitivity, and repeatability of the microscope were not altered by the modifications (see record of calibration in Appendix C).

References

1. J. H. Watt, NFPA Handbook of the National Electric Code, McGraw Hill Book Co., 1972.
2. R. Y. LeVine, W. A. Short, and W. F. Hickes, "Electrical Safety in Process Plants," Chem. Eng., 79:9, 5 (1972).
3. W. E. Seuberling, Electrical Equipment for Hazardous Locations, Mound Laboratory, 1965.

*The melting point for PETN (a secondary explosive) is 140°C (284°F), and the decomposition temperature is 206°C (403°F).

Appendix A.

Operational Procedures

The Leitz Universal Toolmakers' Microscope when used in either the laboratory or workshop is both universal and highly accurate in its applications. If properly installed and maintained, it proves to be simple to operate and easily determines linear or angular measurements.

These measurements are determined by presenting the workpiece to the measuring table or any suitable staging or holding fixture. The lower reflecting light (filament lamp for transmitted light) will produce a clear shadow or silhouette of the part to be measured, and the cross hair lines contained in the binocular tube may be positioned as desired by manipulation of the longitudinal and cross feeds. When this has been accomplished a readout may be obtained from the viewing screen. Measurements repeatable to the nearest 0.0001 in. are determined by properly adjusting the two scales provided in the viewing screen. Surface measurements may be determined, using the same techniques, except the shadow or silhouette of the part to be measured cannot be used. Illumination for surface measurement is provided by two incident lights which are either attached to the optical tube or are placed adjacent to the tube.

If an angular measurement is desired, the techniques are the same except the angular measurement is determined by moving the knurled knob on the right side of the head to the proper lineup of the angle and then switching the small level at the bottom of the head. This will bring into view a vernier scale which will give a direct readout of the angle. This scale is illuminated by another incident lamp.

There are several accessories available for special applications, such as special graticules, photographic equipment, monocular or binocular heads, and goniometer eyepieces.

Appendix B.

Appendix C.

Record of Calibration

The Leitz Large Universal Toolmakers' Microscope, Model UWM, (S/N 624543, M-64-2965) was tested before and after explosion proofing modification for straightness of travel of the longitudinal and cross slide, for perpendicularity of the cross slide travel to the longitudinal slide travel, and for linear accuracy of the scales and verniers. The actual time interval between tests was 16 months.

These tests were performed with a Universal Square, a calibrated measuring instrument, and gage blocks certified by the Mound Dimensional Standards Laboratory. The test for scale linearity was made using a Moore 8-in. step master certified by the Primary Standards Laboratory, Sandia Corporation, Albuquerque, New Mexico.

Possible measuring inaccuracies in these tests were ± 0.000025 in. in most cases and probably did not exceed ± 0.000050 in. in any case.

The test results were as follows:

STRAIGHTNESS OF TRAVEL

The longitudinal slide was measured to be within 0.000060 in. (before) and 0.000070 in. (after) in 4 in. of travel.

The cross slide was measured to be within 0.000035 in. (before) and 0.000050 in. (after) in 2 in. of travel.

PERPENDICULARITY OF TRAVEL

The cross slide travel to longitudinal travel was measured to be within 0.000050 in., both before and after the modification, in 3 in. of travel.

ZERO TO EIGHT INCH SCALE CALIBRATION

Nominal (in.)	Deviation from Nominal (0.000001 in.)	
	Before	After
0.00	0	0
1.00	+25	+20
2.00	+25	+30
3.00	+30	+40
4.00	+50	+25
5.00	+25	+10
6.00	+25	+10
7.00	+30	+40
8.00	+60	+50

EIGHT INCH TO ELEVEN INCH SCALE CALIBRATION

<u>Nominal</u> <u>(in.)</u>	<u>Deviation from Nominal</u> <u>(0.000001 in.)</u>	
	<u>Before</u>	<u>After</u>
8.00	0	0
9.00	0	+20
10.00	0	+20
11.00	+50	+70

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