



FMF-OM-924 FMF Fuel Slug Inspection

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Changing the World's Energy Future

C.W. Wilkes



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EBR-II FUEL MANUFACTURING FACILITY OPERATIONS MANUAL

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1. INTRODUCTION

After the cast fuel slugs are sheared to length, they undergo a series of inspections and measurements including:

- visual inspection
- straightness
- radiography
- length
- weight
- diameter and volume

References for the acceptance criteria for fuel slug inspection are listed in the FMF Fuel Slug Manufacturing Process Worksheets. All inspections with the exception of radiography are performed by FMF technicians.

2. EQUIPMENT AND MATERIALS

2.1 The straightness of the fuel slugs is checked by a go-no-go gauge which consists of two parallel plates. The spacing between the plates corresponds to the straightness requirements of the slugs being tested. If the fuel slugs pass between the plates, they are acceptable.

2.2 The radiography facility equipment is operated and maintained by OQA NDE technicians.

2.3 At the length inspection stations the length of the fuel slugs is measured with respect to a standard. A Mitutoyo Digimatic measuring tool at each slug inspection station converts the difference in length between the standard and the fuel slug to a digital electrical signal that is fed to a computer.

2.4 The weight of each fuel slug is measured to 0.01 g by an electronic balance. Each inspection station has a separate balance.

2.5 The fuel slug diameter is determined by a noncontact bench micrometer that uses a scanning laser beam. The information is fed to a computer. A liquid crystal display indicates either the slugs diameter or the measured deviation from a user selected nominal dimension.

2.6 The fuel slug inspection computer equipment consists of a computer, dual disc drive, and printer. The computer is connected to the inspection station through an RS-232 cable and T-switch.

3. OPERATING PROCEDURES

3.1 Precautions

3.1.1 The laser used in the bench micrometer is a low power Class II type and only emits visible red light. The radiant output power of the internal laser and of the instrument is relatively low. The radiation emitted is incapable of burning or drilling holes, even if a lens is used to focus the light. However, the laser light emitted from the micrometer should be treated with caution and common sense. The laser light will not cause skin burns, but care should be taken to not look directly into the laser beam or stare at its bright reflections.

3.1.2 Observe all criticality control rules when transferring fuel slugs to the inspection stations.

3.1.3 Wear protective rubber gloves and a lab coat when handling bare fuel slugs. Follow radiological control rules.

3.2 Straightness Inspection

3.2.1 Ensure the straightness gauge is set for the proper slug diameter.

3.2.2 Roll each slug through the straightness gauge.

3.2.3 Slugs that pass through the gauge are acceptable.

3.2.4 Any slugs that fail to pass through the gauge, after burrs have been removed from the slug, are rejected.

3.2.5 Return any reject slugs to the hood and chop them into lengths short enough to fit in the pin-fines can.

3.2.6 Accepted slugs continue on to visual inspection.

3.3 Visual Inspection

3.3.1 Inspect each slug for voids or shrinkage areas on the external surface that could cause the slug diameter to be less than the minimum acceptable diameter as indicated on the process worksheets.

3.3.2 Check all suspect areas on each slug with a point micrometer.

3.3.3 Return reject slugs to the hood for chopping.

3.3.4 Place the acceptable slugs in a numbered cardboard bandolier.

3.3.5 Transfer the slugs to the radiography facility.

NOTE: Ensure that all material control and accountability and criticality hazards control rules are followed when transferring nuclear material.

3.4 Radiography

3.4.1 Radiography is performed by OQA NDE personnel according to criteria referenced in the FMF Fuel Slug Manufacturing Process Worksheets.

3.4.2 After radiography has been completed, return the fuel slugs to the inspection stations.

3.4.3 Transfer rejected slugs to the hood for chopping.

3.5 Slug Inspection Equipment Startup

3.5.1 Turn on the computer, disc drive, and printer.

3.5.2 Turn on the balance.

3.5.3 Turn on the length gauge.

3.5.4 Turn on the bench micrometer.

3.6 Slug Inspection Equipment Calibration

NOTE: The balance should be on at least 1/2 hr before use.

3.6.1 Balance calibration.

3.6.1.1 Depress the tare bar to zero the balance.

3.6.1.2 Calibrate the balance with a 500 g weight.

3.6.1.3 Check Table 1 for calibration limits.

3.6.2 Place the length standard in the length gauge and press the zero button.

3.6.3 Bench micrometer calibration.

3.6.3.1 Place the diameter standard in the length gauge.

3.6.3.2 Open the window covers on the bench micrometer.

3.6.3.3 Press the "Second Function" key on the key pad.

3.6.3.4 Press the "Continuous" key.

3.6.3.5 Press the "Enter" key.

3.6.3.6 Press the "Go" key.

3.6.3.7 Pull the diameter standard through the laser beam.

3.6.3.8 Check that the indicated diameter matches the standard (see Table 1).

3.7 Fuel Pin Inspection

3.7.1 Load the "Pin Process Disc" into the :D701 disc drive.

3.7.2 Load a blank initialized disc into the :D700 disc drive.

3.7.3 Enter LOAD"PPAR30:D701" and press ENDLINE.

3.7.4 Press the RUN key.

3.7.5 Enter information for batch number, composition, enrichment, date, time, length standard, slug diameter, number of slugs, radiography reject slugs, and file name.

3.7.6 Remove the first slug from the bandolier and carefully center it on the balance saddle.

3.7.7 Move the T-switch to the weight position.

3.7.8 When the balance has stabilized, press the weight button.

3.7.9 Place the slug in the length gauge.

3.7.10 Move the T-switch to the length position.

3.7.11 Press the length switch.

3.7.12 Leave the slug in the length gauge and push the length gauge to the full back stop.

3.7.13 Move the T-switch to the diameter position.

3.7.14 On the bench micrometer, press the "Second Function" key.

3.7.15 Press the "Data Reset" key.

3.7.16 Press the "Enter" key.

3.7.17 Press the "Go" key.

3.7.18 Pull the length gauge to the full forward stop.

3.7.19 Push the length gauge to the full back stop.

3.7.20 Press the "Second Function" key.

3.7.21 Press the "Count" key.

3.7.22 Press the "Minimum" key twice.

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- 3.7.23 Press the "Maximum" key twice.
 - 3.7.24 Press the "Average" key.
 - 3.7.25 Press the "Second Function" key.
 - 3.7.26 Press the "STD.DEV" key.
 - 3.7.27 Remove the slug from the length gauge and return it to its proper position in the bandolier.

NOTE: The fuel slug identity is established by the sequential order of radiographic inspection. The slug identity on the computer printout must always correspond to its position in the bandolier.

3.7.28 Repeat steps 3.7.6 through 3.7.32 for each slug in the batch. Periodically verify that the printout identity corresponds to the bandolier position.

3.7.29 After all slugs in the batch have been inspected, recheck the equipment per section 3.6. If the equipment is not in calibration, all slugs inspected since the last calibration must be reinspected.

3.7.30 Any slugs that were rejected during fuel slug inspection shall be reinspected per section 3.8.

3.8 Fuel Slug Reinspection

3.8.1 Rerun the "PPAR30" program per steps 3.7.3 and 3.7.4.

3.8.2 Enter information for batch number, composition, enrichment, date, time, length standard, slug diameter, and number of slugs to be reinspected.

3.8.3 Create a new file name.

3.8.4 Reinspect the slugs per steps 3.7.6 through 3.7.30.

3.8.5 Reinspected slugs that meet the acceptance criteria on reinspection are acceptable.

3.9 File Merge

NOTE: If any slugs in the batch were reinspected, the file merge program must be run.

3.9.1 Enter LOAD "PinMRGA:D701" and press ENDLINE (the PinMRGA program is on the Pin Processing disc).

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- 3.9.2 Press the RUN key.
 - 3.9.3 Input the first file name.
 - 3.9.4 Input the second file name.
 - 3.9.5 If necessary, input the third file name, otherwise press ENDLINE.
 - 3.9.6 If necessary, input the fourth file name, otherwise, press endlne.
 - 3.9.7 If necessary, input pin identities to be deleted, otherwise press ENDLINE.
 - 3.9.8 Press the MERGE key.
 - 3.10 Slug Printout
 - 3.10.1 Enter LOAD"pINS 10" and press ENDLINE (the "pINS 10" program is on the Pin Processing disc).
 - 3.10.2 Press the RUN key.
 - 3.10.3 Input the file name.
 - NOTE: The filename will be a merged file if reinspected slugs were recovered, otherwise the filename will be an accept file.
 - 3.10.4 Press the PRINTOUT key.
 - 3.10.5 Repeat steps 3.10.3 and 3.10.4 twice (three printouts are required).
 - 3.10.6 Place two slug printouts in the process work package.
 - 3.10.7 Forward one slug printout to the Records Technician.
 - 3.11 Slug Disc
 - 3.11.1 Remove the Pin Processing disc from disc drive :D701.
 - 3.11.2 Place a blank initialized disc in disc drive :D701.
 - 3.11.3 Copy the accept or merged slug file to the blank disc by entering COPY "Filename:D700" TO "Filename:D701" and pressing ENDLINE.
 - 3.11.4 When the copy is complete, remove the discs from both disc drives.
 - 3.11.5 Place one disc in the process work package.

3.11.6 Forward one disc to the Records Technician.

3.12 Shutdown Procedure

3.12.1 Turn off power to the computer, disc drive and printer.

3.12.2 Turn off power to the length gauge and bench micrometer.

3.12.3 Close the window covers on the bench micrometer.

3.12.4 If necessary, follow the Radiation Safety Technician's directions for decontaminating the slug inspection stations.

3.1.2.5 Ensure that the applicable steps of the Process Worksheet have been completed.

3.13 Emergency Shutdown Procedure

If the safety of the Operating Technicians is not jeopardized, shut down the equipment per Section 3.12. If a building evacuation is necessary, follow the FMF Emergency Procedures.

4. MANUAL FUEL SLUG INSPECTION

4.1 Diameter Inspection

4.1.1 Micrometers used for diameter inspection shall be readable to .0001 in. and calibrated to .0001 in. by the calibration lab. A calibration sticker shall be in place indicating the last calibration date.

4.1.2 Check the micrometer before and after each batch of fuel slugs by using standards that are both larger and smaller than the slug diameter.

4.1.3 Start 1/4 in. from the end of the slug and measure slug diameter every inch.

4.1.4 Analyze the data with a computer program. The average diameter is defined as the unweighted average of all measured valves.

4.2 Length Inspection

4.2.1 Vernier calipers used for length inspection shall be readable to .001 in. and calibrated to .001 in. by the calibration

lab. A calibration sticker shall be in place indicating the date of the last calibration.

4.2.2 Check the caliper before and after each batch of slugs by using standards that are both longer and shorter than the slugs.

4.2.3 Record slug lengths on the Process Worksheets and enter them in the computer data base.

4.3 Data Acquisition

4.3.1 Each slug is identified by batch number and a pin number. The slug data are analyzed by a computer program and a printout is made that, as a minimum, includes for each slug:

- average diameter
- maximum diameter
- minimum diameter
- length
- straightness
- volume
- weight
- density

4.3.2 In addition the computer program prints these batch data as a minimum:

- number of accepted slugs
- total weight of accepted slugs
- average density
- average diameter

5. MAINTENANCE

5.1 The inspection equipment shall be maintained or calibrated in accordance with the following schedule:

| <u>Equipment</u> | <u>Schedule</u> | <u>Tolerance</u> |
|-------------------------------------|-----------------|---|
| • Balance, clean and adjust | 12 months | In accordance with manufacturer's standards |
| • Length standards, recertification | 12 months | ± 0.01 in. |

| <u>Equipment</u> | <u>Schedule</u> | <u>Tolerance</u> |
|---------------------------------------|-----------------|------------------|
| • Weight standards, recertification | 12 months | ± 0.0025 g |
| • Diameter standards, recertification | 12 months | ± 0.001 in. |

5.2 The balances shall be maintained by either the EG&G calibration lab or a factory representative.

5.3 The FMF Calibration Custodian is responsible for coordination of standards recertification by the EG&G Standards Lab.