INL/MIS-21-65224-Revision-0

FMF-OM-921 PWS, FMF Injection Casting

December 1986

C.W. Wilkes

Changing the World's Energy Future

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Contract DE-AC07-05ID14517

EBR–II FUEL MANUFACTURING FACILITY
OPERATIONS MANUAL

REVIEW AND APPROVAL

REV. BUL. NO. 781 DATE 12/15/86

SECTION FMF-OM-921

TITLE PWS, FMF INJECTION CASTING

REVIEW

SIGNATURE		DATE
D. F. Dallacker QUALITY ENGINEER/QCA	Lee Speed Ste 12/19	12/19/86
C. E. Hobson RADIATION, FIRE AND SAFETY ENGINEERING		1-6-87
D. B. Tracy		1/27/87

APPROVAL

SIGNATURE	DATE
EBR–II DIVISION QUALITY ENGINEER	1-13-87
SUPERVISOR	1-22-87
FABRICATION DEVELPMENT MANAGER	1-27-87
FUEL MANUFACTURING MANAGER	1/27/87

OPER. NO.	INSTRUCTIONS	SIGNOFF	DATE	DISPOSITION	
				ACC	I/DR
1.0	Sect. Mgr./Asst. Sect. Mgr. - Authorize fabrication of fuel slugs.				
2.0	Oper. Tech. - Issue the process package containing the following: (a) Process Work Sheets (FMF-OM-921) (b) Injection casting sheets: (1) Fuel Slug Specification Summary Sheet (2) Casting Parameter Sheet (3) Furnace Log for Injection Casting (4) Flow Sheet for Injection Casting (5) Analytical Summary Sheet (6) Injection Casting Input Sheet (7) Casting Flow Sheet				
3.0	Supr. Fuel Slug Manuf. - Complete applicable sections of data sheets.				
4.0	Oper. Tech. - Transfer charge materials to casting area.				
5.0	Oper. Tech. - Weigh charge materials and complete the Injection Casting Input Sheet per FMF-OM-920.				
6.0	Oper. Tech. - Coat molds per FMF-OM-922.				
7.0	Oper. Tech. - Coat crucibles per FMF-OM-922.				
	7.1 Complete Materials Check List.				
	7.2 Complete the Preoperational Check List for Injection Casting.				

OPER. NO.	INSTRUCTIONS	SIGNOFF	DATE	DISPOSITION ACC	DISPOSITION I/DR
8.0	Oper. Tech. - Make injection casting per FMF-OM-920.				
9.0	Oper. Tech. - Demold, shear, and sample the slugs and break the heel per FMF-OM-923.				
10.0	Oper. Tech. - Transfer slugs to the slug processing station and inspect all slugs for the following attributes and acceptance criteria per the Fuel Slug Specification Summary Sheet or Specification #_____.				
	10.1 Straightness				
	10.2 Ends and Surface				
11.0	Oper. Tech. - Place fuel slugs in a numbered spacer, and transfer the slugs in a birdcage to radiography. Forward the process package with the slugs. Leave the birdcage in radiography until the radiographic inspection is completed.				
12.0	NDE - Radiographically inspect slugs for internal defects per NDE-63.				
	12.1 NDE - Radiograph slugs per Specification #_____ _____				
	12.2 NDE - Special instructions: _____ _____ _____ _____ _____ _____ _____ _____ _____				

OPER. NO.	INSTRUCTIONS	SIGNOFF	DATE	DISPOSITION ACC	DISPOSITION I/DR
13.0	Oper. Tech. - Transfer fuel slugs to the slug inspection area. Forward radiographs to the Supr. Fuel Slug Manuf.				
14.0	Oper. Tech. - Calibrate the slug inspection equipment and inspect all fuel slugs for diameter, length and weight per FMF-OM-924. Return rejected slugs to the fuel slug spacer and hold for reinspection. Mark the spacer with the cause of rejection. Recalibrate the processing equipment and reinspect the reject fuel slugs.				
	NOTE: Inspect suspect slugs having external voids or shrinkage areas with a point micrometer, or laser profilometer.				
	14.1 If possible, rework and reinspect salvageable slugs. (NA this blank if not necessary.)				
	14.2 If necessary, manually input slug processing data into the computer. (NA this blank is not necessary.)				
	14.3 Read fuel slug data printout. All fuel slugs must be accepted by computer verification.				
	14.4 Document nonconforming slugs with an Inspection/Disposition Report (IDR). Log in IDR's with QA.				
15.0	Oper. Tech. - Chop reject slugs per FMF-OM-923. Put chopped slugs and pin fines in a can with material from demolding				

OPER. NO.	INSTRUCTIONS	SIGNOFF	DATE	DISPOSITION ACC	DISPOSITION I/DR
	and shearing. Reweigh cans and mark weight on the cans. Record weights on the injection casting flow sheet. 15.1 Oper Tech. - Send waste material (fine-fines, glass and dust, crucible) to NDA and then to the FMF vault.				
16.0	Oper. Tech. - Weigh accepted fuel slugs in the spacer. Gross weight _____ g Spacer tare _____ g Net fuel slug wt. _____ g				
17.0	Oper. Tech. - Store accept slugs in a birdcage.				
18.0	Oper. Tech. - Complete the injection casting flow sheet and forward a copy to the FMF MBA custodian.				
19.0	Oper. Tech. - Computer total fuel slug weight must agree with measured net fuel slug weight (Oper. No. 16) within ± 0.1%. Retain the computer report with the process package.				
20.0	Oper. Tech. - Record analytical results on the Analytical Summary and verify completeness and acceptability. Notify Supr. Fuel Slug Manuf. if any results are unaccept- able according to specifications.				
21.0	Supr. Fuel Slug Manuf. - Review the fuel slug batch process record.				

OPER. NO.	INSTRUCTIONS	SIGNOFF	DATE	DISPOSITION ACC	DISPOSITION I/DR
	21.1 All Process Work Sheet operations are properly signed off.				
	21.2 All Inspection/Disposition Reports have been reviewed, accepted and completed.				
	21.3 Any nonconformances proposed for acceptance have been approved.				
	21.4 A letter has been written comparing NDA and production values for coldline scrap. NOTE: This step is performed only to verify material balance for material control and accountability. It does not have to be completed before fuel slugs are accepted for reactor use.				
	21.5 All process record sheets listed in Oper No. 2.0 have been completed and attached.				
	21.6 Computer output data are satisfactory.				
	21.7 Chemistry results are satisfactory.				
	21.8 Send copies of these sheets to the MBA custodian. • Analytical Summary • Injection Casting Input Sheet • Casting Flow Sheet • Flowsheet for Injection Casting				

OPER. NO.	INSTRUCTIONS	SIGNOFF	DATE	DISPOSITION ACC	DISPOSITION I/DR
22.0	MBA Cust. - Accountability records are complete. Necessary adjustments have been made.				
23.0	Sect. Mgr./Qual. Eng./Experimenter - Fuel slugs are acceptable for reactor use. Complete the "Approved for Reactor Use" tag. Sect. Mgr. Supr. Fuel Slug Manuf. *Experimenter				
24.0	Supr. Fuel Slug Manuf. - Verify that reject slugs have been removed from the slug spacer.				
25.0	Supr. Fuel Slug Manuf. - Attach the "Approved for Reactor Use" tag to the birdcage containing the slugs.				
26.0	Oper. Tech. - Transfer the birdcage with the accepted slugs to the FMF vault.				
27.0	Oper. Tech. - Forward the process package to the Records File for retention.				

* Experimenter sign-off required only on experimental fuel slug packages. NA this blank for production (MK-II) type fuels.

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FUEL SLUG SPECIFICATION
SUMMARY SHEET

EXPERIMENT/PROJECT _____

APPLICABLE DRAWING NUMBER/SPECIFICATION NUMBER: _____

_____

BUYER/EXPERIMENTER: _____

PHYSICAL REQUIREMENTS

(Not applicable if specification number is given)

LENGTH: _____ + _____ - _____

AVERAGE DIAMETER: _____ + _____ - _____

LOCAL DIAMETER: MIN = _____ MAX. = _____

STRAIGHTNESS: _____

APPARENT DENSITY: _____

RADIOGRAPHY: _____

_____

OTHER: _____

_____

CHEMICAL REQUIREMENTS

(Not applicable if specification number is given)

NOMINAL ALLOY DESIGNATION	TOTAL URANIUM (wt%)	TOTAL PLUTONIUM (wt%)	TOTAL ZIRCONIUM (wt%)	U-235 / U-TOTAL (%)	OTHER
	±	±	±	±	
	±	±	±	±	
	±	±	±	±	
	±	±	±	±	
	±	±	±	±	
	±	±	±	±	
	±	±	±	±	
	±	±	±	±	

ADDITIONAL REQUIREMENTS

(Not applicable if specification number is given)

SAMPLING REQUIREMENTS:

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CASTING PARAMETER SHEET

FMF - INJECTION CASTING

Date: _____ Batch No. _____

1. Casting vacuum _____ m torr
2. Casting temperature _____ °C
3. Mold preheat temperature _____ °C
4. Accumulator pressure _____ psig
5. Pressurization rate _____ psia/sec.
6. Melting Atmosphere (vacuum/argon) _____ (m torr/cfm) @ _____ psig
7. Hold time @ temperature _____ min @ _____ °C
8. Archives required _____
9. Stirring frequency @ time: _____ @ _____ min.
10. Additional stirring @ time: _____ @ _____ min.
11. Other information: _____

_____

_____

_____

_____

_____

Responsible Engineer _____

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ANALYTICAL SUMMARY

Batch No. _____

Sample Wt. _____ Nominal Batch Composition _____

Slug No. _____ Nominal Batch ^{235}U Enrichment _____

ATTRIBUTE	ANALYZED COMPOSITION		
	Top	Center	Bottom
Total Pu			
^{239}Pu			
^{240}Pu			
^{241}Pu			
^{242}Pu			
Total U			
^{234}U			
^{235}U			
236U			
^{238}U			
Zr			
Density			
Other			

Initial if not applicable. _____

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INJECTION CASTING INPUT SHEET

Enriched Uranium _____ Wt. _____g

Depleted Uranium _____ Wt. _____g

Alloy Material _____ Wt. _____g

Heel: IC _____ Wt. _____g

Heel: IC _____ Wt. _____g

Pin Fines IC _____ Wt. _____g

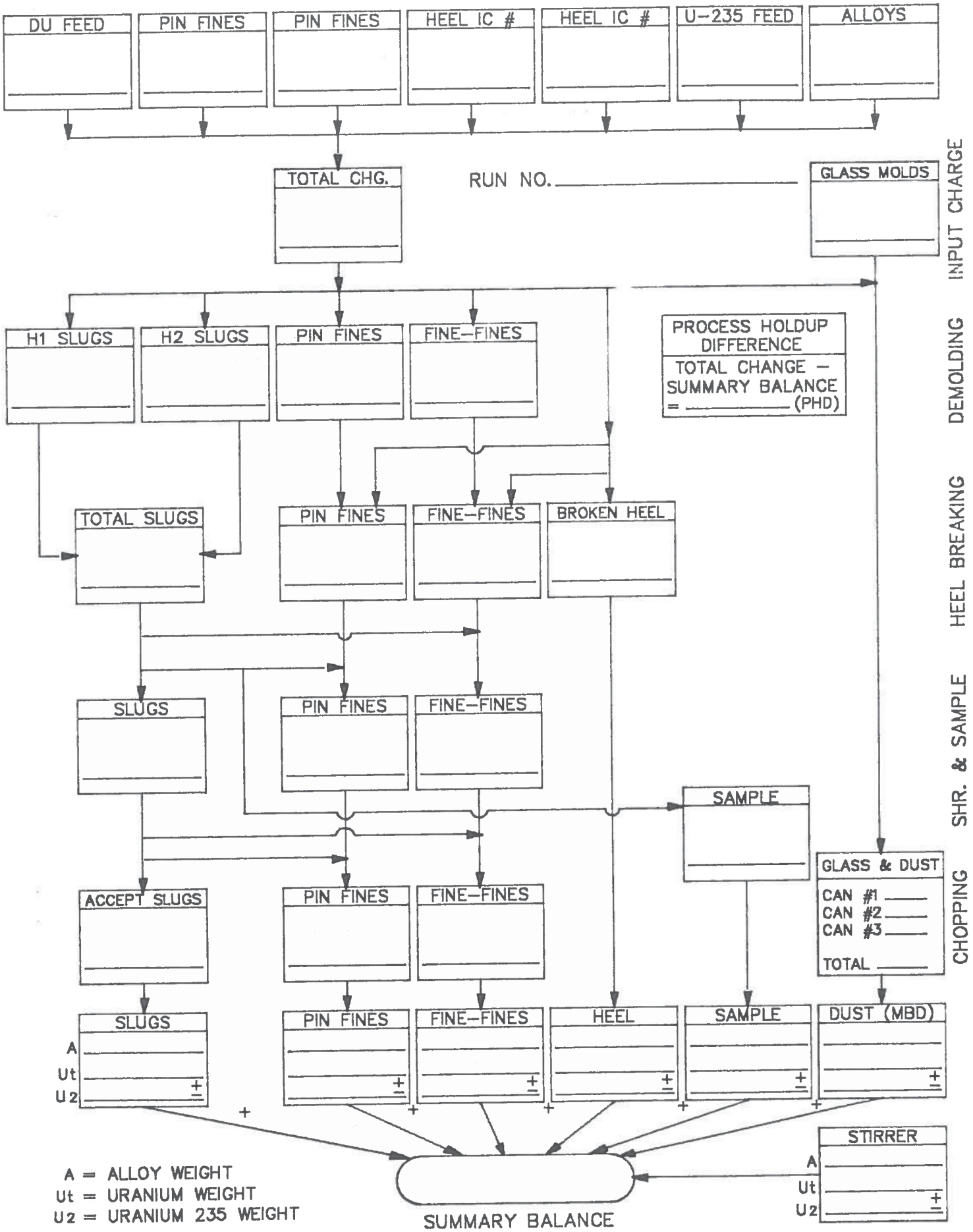
Pin Fines IC _____ Wt. _____g

Total Wt. _____g

Number of molds required _____

Operating Technician _____

Initial if not applicable. _____



FLOWSHEET FOR INJECTION CASTING

T/P FM-80062-X
REV. 2 2/87

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CHARGE CALCULATION SHEET FOR EBR-II DRIVER FUELS

BATCH NO. _____

1. Uranium Melt Stock

   A.

No.	SPM Wt.
_____	_____
_____	_____

   B. Total Uranium _____

2. A. Calculated Charge Input - 1B/0.95 _____

3. A. Calculated Alloy Additions

	%		Weight
Mo	2.44	x 2A/100 =	_____
Ru	1.94	x 2A/100 =	_____
Rh	0.28	x 2A/100 =	_____
Pd	0.19	x 2A/100 =	_____
Zr	0___	x 2A/100 =	_____
Nb	0.015	x 2A/100 =	_____
Si	0.0__	x 2A/100 =	_____

   B. Total Alloy Input _____

4. A. Total Virgin Charge Input (1B+ 3B) _____

Initial if not applicable _____

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ANALYTICAL SUMMARY

BATCH NO. _____

SAMPLE WT _____

PIN # _____

ATTRIBUTE	CRITERIA	ANALYZED COMPOSITION TOP (1)	CENTER	BOTTOM (1)
TOTAL U	94.00/96.00 w/o			
U234				
U235	66.22/67.22 w/o			
U236				
U238				
Mo	2.27/2.61 w/o			
Ru	1.69/2.19 w/o			
Rh	0.23/0.33 w/o			
Pd	0.15/0.23 w/o			
Zr	0.025/0.145 w/o			
Nb + Ta	0.008/0.039 w/o			
Si	0.023/0.085 w/o			
Al	400 ppm			
B	100 ppm			
C	600 ppm			
Cr	300 ppm			
Cu				
Fe	300 ppm			
Mg				
Mn				
Ni	250 ppm			
N	200 ppm			
O	200 ppm			
Y	100 ppm			
Total Impurities	1600 ppm max			

(1) Top and Bottom Samples Required Every 10th Run.

(2) If individual impurity ppm levels are exceeded, report results to the Fuels and Materials Department Buyer for approval.

Fuels & Materials Buyer: Initial if exceeded individual impurity values are acceptable and an IDR is not required. _____

Initial if not applicable _____

FURNACE LOG FOR INJECTION CASTING

Run No. _____ Date _____

Time	Volts	Vac./ Flow	Temp °C TC#1	TC#2	Pyro	Oil	Mold	Cap	%kW	%KVAR	%A	Init	Remarks

Shield Opening Temp. _____ °C _____ mV

Start Casting Cycle _____ °C

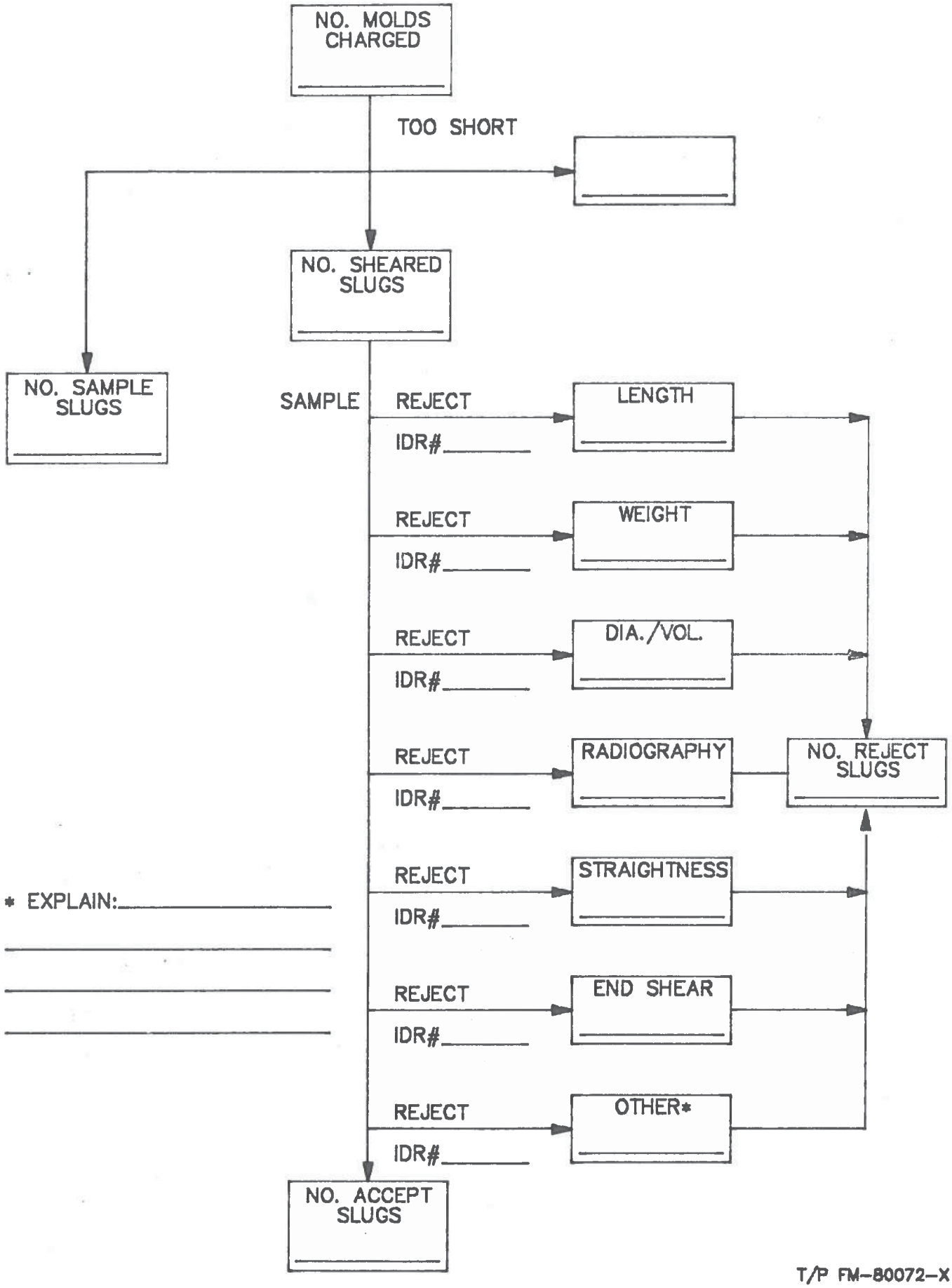
PREOPERATION CHECKLIST FOR INJECTION CASTING

Op.Tech.	1. ___	Mold/crucible clearance has been checked and is acceptable.
Op.Tech.	2. ___	The melt T.C.'s have been verified operational.
Op.Tech.	3. ___	The tophat preheater T.C.'s have been verified operational.
Op.Tech.	4. ___	The furnace door and tophat flange are secured.
Op. Tech.	5. ___	All furnace door bolts and tophat flange bolts have been torqued down.
Op.Tech.	6. ___	The electrical guards are in place and secured around the bottom of the furnace.
Op.Tech.	7. ___	All air/argon lines have been connected and fittings tightened.
Op.Tech.	8. ___	The furnace cooling water valve is open and cooling water flow is verified.
Op.Tech.	9. ___	The H.P. has released the furnace room for operation.
Superv. **(Lead Tech)**	10. ___	The preoperational checklist is complete. The injection casting furnace is ready for operation.

MATERIALS CHECKLIST

	Type	No. Used	*Reused
Molds			
Crucible			
T.C. Wire			
Enriched-U			
Depleted-U			
Zr			
Mo			
Ru			
Rh			
Pd			
Si			
Nb			
Ta Stirrer			
T.C. Well			

* Reused column completed with a (Yes) or (No).



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CASTING FLOW SHEET