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TR-653-240-004

COVER SHEET

DOCUMENT TITLE	AUTHOR
Machining Capability of Hobbing SNAP Cladding Fins	F. C. Schrag

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SUPPORTING DOCUMENT

NUMBER	REV LTR/CHG NO.
TR-653-240-004	SEE SUMMARY OF CHG

PROGRAM TITLE

Space Power Facility Reactor

DOCUMENT TITLE

Machining Capability of Hobbing SNAP Cladding Fins

DOCUMENT TYPE: Test Report

KEY NOUNS: Machining Capability, SNAP Clad Fins

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PREPARED BY/DATE		DEPT	MAIL ADDR
F.C. Schrag	7-7-71	737-72	LB45

APPROVALS — DATE

D.C. Campbell 7/9/71

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* Title Page plus Table 1

ABSTRACT

Three helical fins were machined on fifty-one Incoloy 800 cladding tubes by hobbing. This machining technique was to meet SNAP dimensional requirements. The inspection data are presented along with a summary dimensional analysis.

A number of actual dimensions did not meet drawing requirements; however, a statistical analysis of the data showed that the hobbing operation did control all critical dimensions within print tolerances. It is concluded that a high yield can be achieved by improving the machine set-up technique and performing first piece inspection before machining a quantity of parts.

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FORM 734 C REV 8 70

I. OBJECTIVE

The objective of this test was to establish the machining capability of hobbing fins on SNAP cladding.

II. DISCUSSION

In order to provide coolant mixing within the SNAP 8 reactor core, it is desirable to have helical fins machined on some of the fuel elements.(1) An example of a finned element with a thermocouple attached is shown in Figure 1. The detailed drawing of a finned cladding tube is shown in Figure 2. The technique used to machine helical fins is hobbing.(2)

Fifty Incoloy 800 tubes approximately 21 inches long were machined by hobbing. The machining was performed by Gear Supply & Broaching Co., authorized by P.O. #N1150070. The starting material was .540 inch ID by .050 inch wall thickness. The tubing was procured on P.O. #N700803 and was within the requirements of ST0160NB0037, "Ni, Fe, Cr Alloy Wrought Products." Data for the starting tubing are published in Reference 3.

III. PROCEDURE

Each tube was placed on a mandrel and placed between centers of the hobbing machine as shown in Figure 3. A tube support bushing, mounted to the hob cutter carriage, supported the tube. This tooling arrangement reduced tool chatter and assured a good surface finish.

The ends of the tubes without fins were machined on a grinding machine. Machining the tube ends on this second machine produced an undercut at the

end of the fins. The undercut was exaggerated by a lack of concentricity between the ends and the finned section.

Dimensions of the tubes were recorded after hobbing. Copies of the data sheets are attached. The wall thickness was measured with a Vidigage. Four thickness readings were recorded for each of 5 positions along the length of the tubes. Tube length, fin length, helical pitch and fin width were measured with micrometers and calipers. The radius at the root of the fin and fin end were measured with a radius gage, and undercut at the end of the fins was measured with an optic comparator. The inside diameter was measured with a trimicrometer. Surface finish was measured with a profilometer and verified with visual standards of milling machine finishes.

IV. SUMMARY OF DATA

A summary of the dimensional data is presented in Table 1. Dimensional averages and corrected standard deviations are presented. Results of a comparison of the dimensions with the drawing requirements are tabulated in Table 2. The dimensions which do not meet the print requirements are the finned length, unfinned length, helical pitch, and wall thickness. A comparison of 3 sigma dimension values, with respect to the drawing tolerances, show the fin length sigma value is the only one which exceeds the specified tolerance requirement.

V. ATTACHMENTS

Attached to this report are copies of:

1. Purchase order for hobbing.
2. Receiving inspection data.
3. Inspection Internal Discrepancy Report (IDR).
4. Trip Report to Gear Supply Co.

VI. CONCLUSIONS

The hobbing process will generate acceptable helical fins on the outside of SNAP 8 fuel elements. The three sigma values for the dimensions are within the tolerance requirements shown on the drawing, Fig. 3. Some nominal dimensions were grossly outside the nominal requirements; therefore, the product was rejectable. Improvement in machine setup will eliminate these rejected conditions. Assurance of proper machine setup could be achieved by inspecting the first few parts machined at the vendor's plant.

VII. REFERENCES

1. IL, E. Moody to E.J. Donovan, "Scalloped Fins," 3-19-71
2. Lawrence E. Doyle, "Manufacturing Processes and Materials for Engineers"
3. T.D. Williams, "Receiving Inspection Incoloy 800 Fuel Cladding," 3-22-71

FORM 719-r REV. 8-69

TABLE 1

SUMMARY OF DIMENSIONAL DATA

Item	$\bar{X}$	S	3 Sigma	Actual	Specification Requirement
Overall Length	20.999	.0057	.017	20.999 ± .017	21.00 ± .030
Unfinned Area Length	1.955	.0073	.022	1.955 ± .022	2.00 ± .030
Finned Area Length	16.524	.014	.042	16.524 ± .042	16.50 ± .030
ID (3/4" from End 1)	.5395	.00014	.00042	.5395 ± .0004	.540 ± .001
ID (3¼" from End 1)	.5394	.0001	.0003	.5394 ± .0003	.540 ± .001
ID (3¼" from End 2)	.5394	.0001	.0003	.5394 ± .0003	.540 ± .001
ID (3/4" from End 2)	.5391	.0001	.0003	.5391 ± .0003	.540 ± .001
Fin Width	.074	.0009	.0027	.074 ± .003	.070 ± .010
TIR	.003	.0015	.0045	.003 ± .0045	.012 Max.*
Pitch	5.587	.0013	.0039	5.587 ± .004	5.50 ± .030
Undercut	.0017	.0007	.0021	.0017 ± .002	.001 Max.*

* Specification ST0115NA0019

TABLE 2

COMPARISON OF DIMENSIONS
TO SPECIFICATION REQUIREMENTS*

Item	Number Accepted	Number Rejected
Overall Length	10	0
Unfinned Area Length	0	10
Finned Area Length	8	2
Pitch Length	0	10
End of Fin Radius	10	0
ID	10	0
F_n Width	10	0
Fin Radius (Fillet)	10	0
Wall Thickness	0	10
TIR	10	0
Undercut	10	0

* Sample of 10 pcs

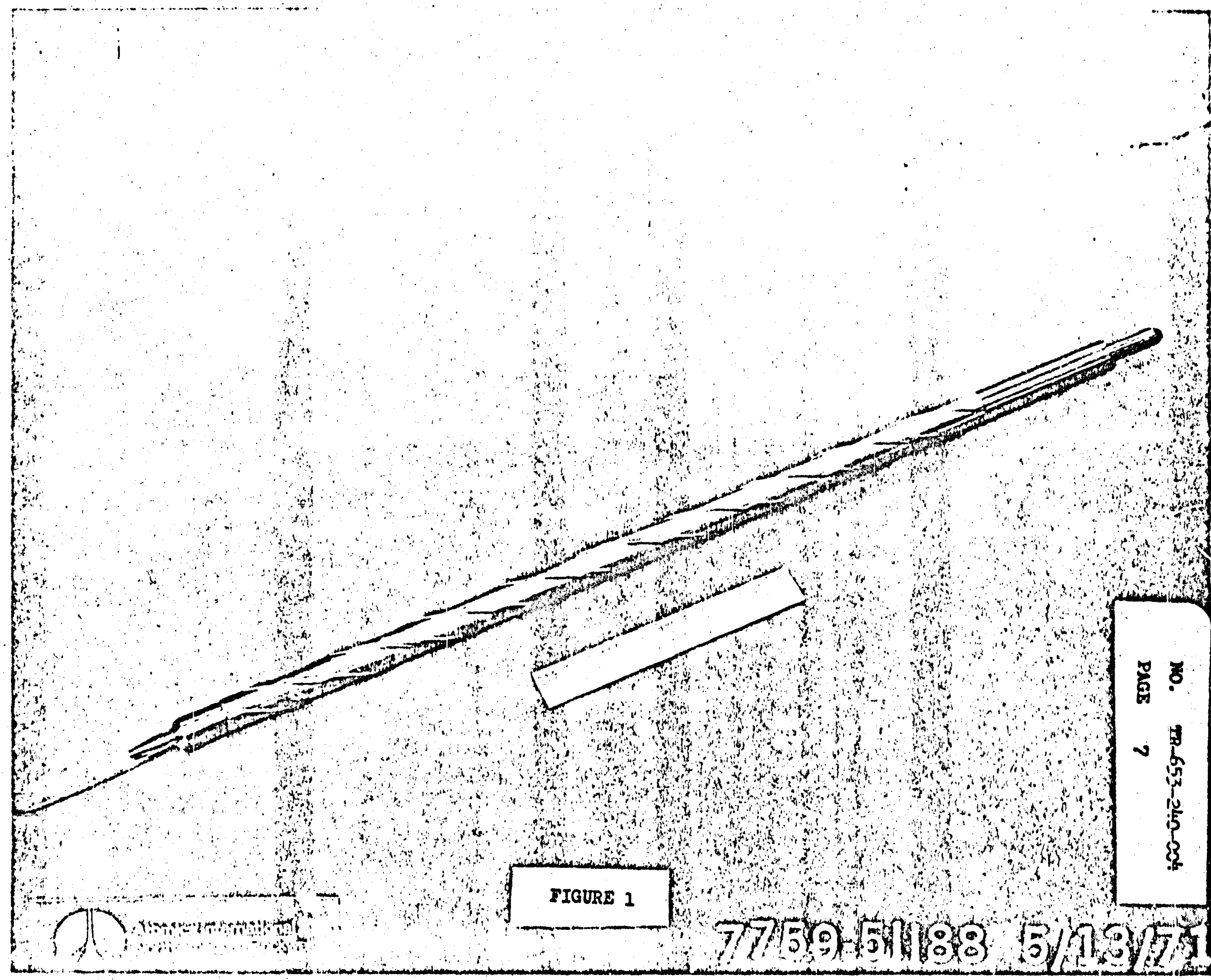


FIGURE 1

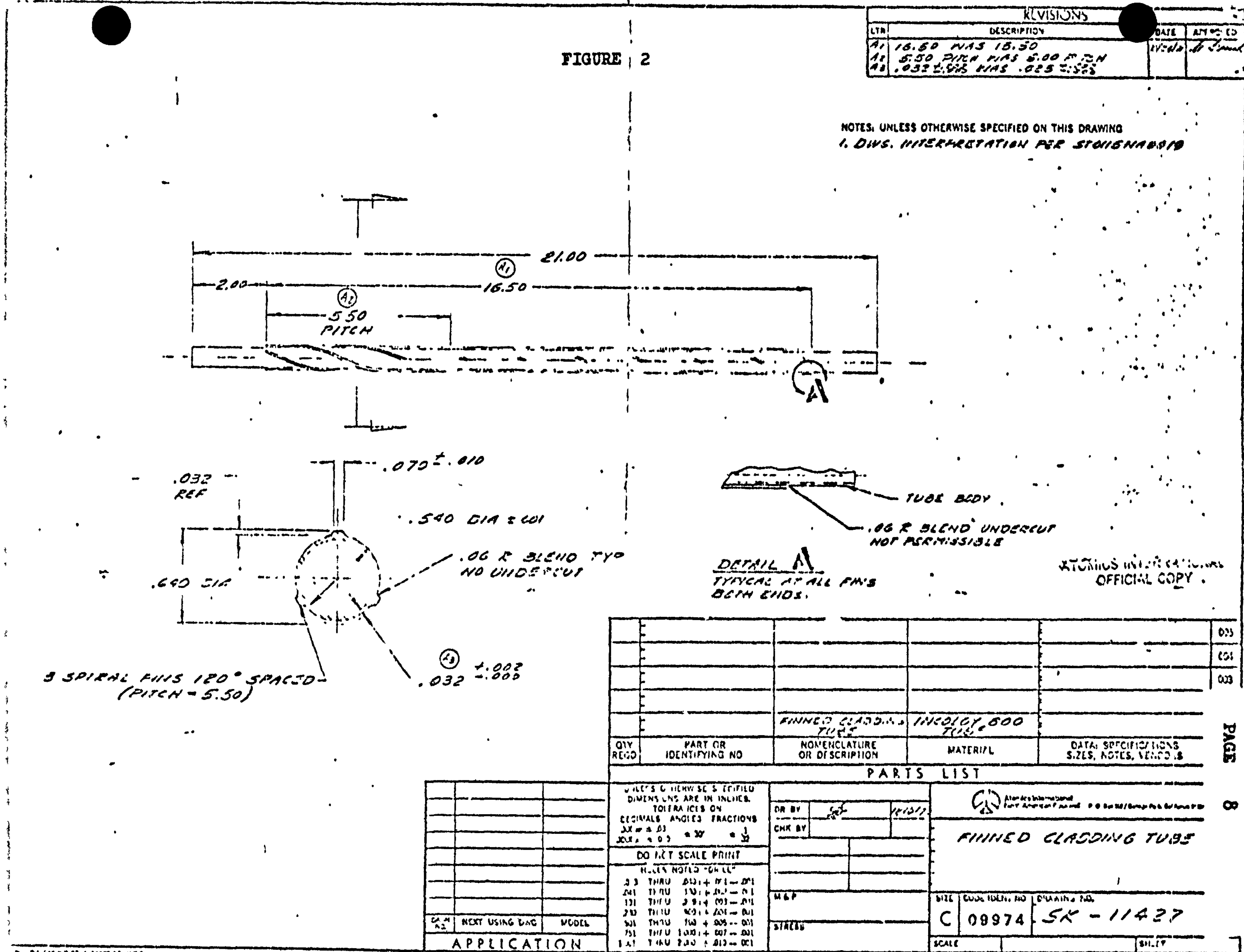

REVISIONS
LTR DESCRIPTION DATE APPROVED
A1 16.50 WAS 15.50
A2 5.50 PITCH WAS 5.00 PITCH
A3 .032 DIAS WAS .025 DIAS
NOTES: UNLESS OTHERWISE SPECIFIED ON THIS DRAWING
1. DWG. INTERPRETATION PER
21.00
2.00
16.50
5.50 PITCH
.070 ± .010
.032 REF
.540 DIA ±.001
.640 DIA
.06 R BLEND TYP NO UNDERCUT
3 SPIRAL FINS 120° SPACED (PITCH = 5.50)
.032 +.002 -.000
TUBE BODY
.06 R BLEND UNDERCUT NOT PERMISSIBLE
DETAIL A
TYPICAL AT ALL FINS BOTH ENDS.
OFFICIAL COPY
FINNED CLADDING TUBE
INCOLOY 800 TUBE
QTY REQD
PART OR IDENTIFYING NO
NOMENCLATURE OR DESCRIPTION
MATERIAL
DATA: SPECIFICATIONS SIZES, NOTES, VENDORS
PARTS LIST
NEXT USING DWG
MODEL
APPLICATION
DO NOT SCALE PRINT
DR BY
CHK BY
STRESS
FINNED CLADDING TUBE
SIZE
C
CODE IDENT NO
08974
DRAWING NO.
SK - 11427
SCALE
SHEET

FIGURE 2

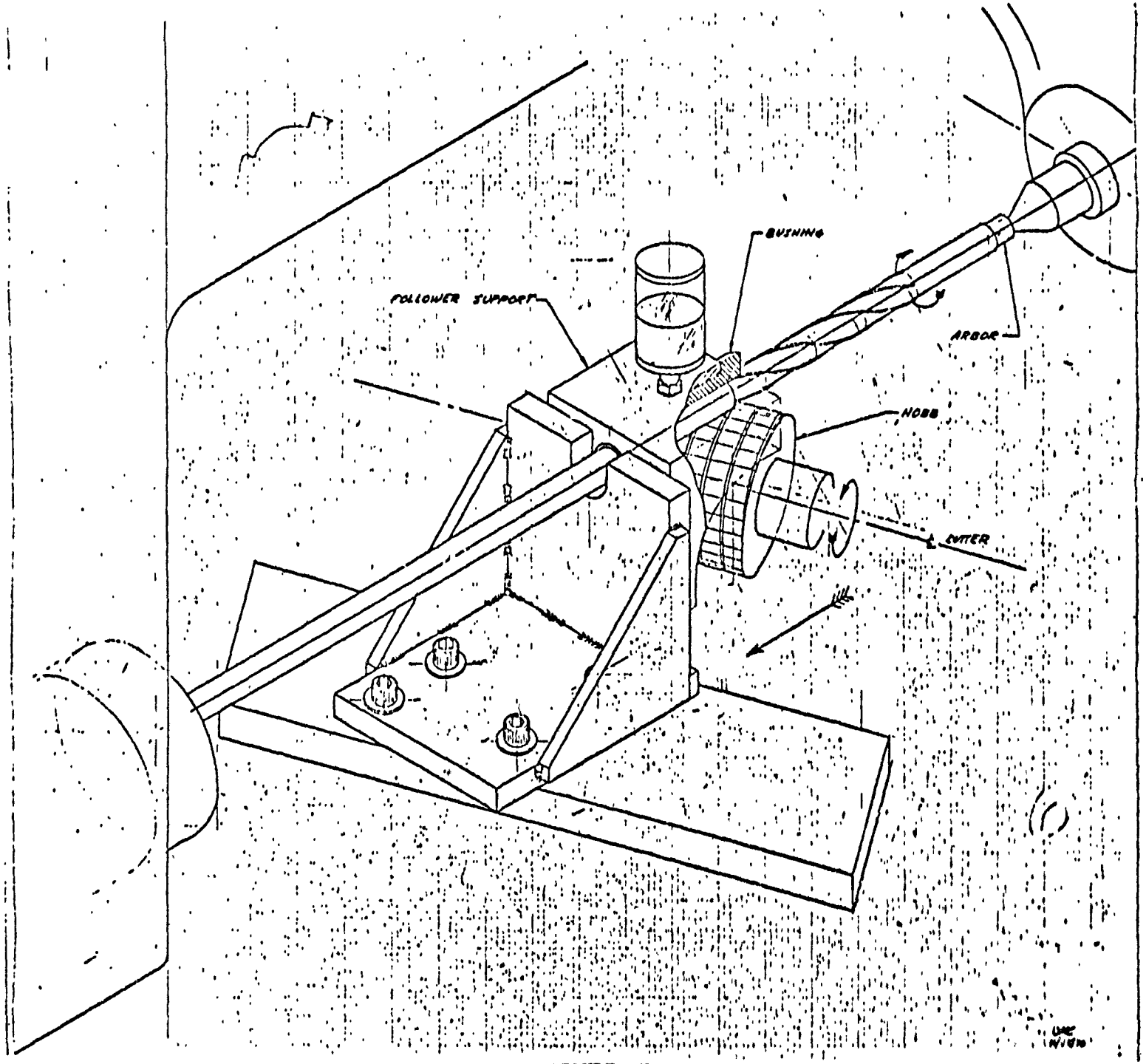


FIGURE 3

REQUISITION NO. 38912

CHANGE REQUEST / INTERNAL CHANGE ONLY

14651 | 9172118 | S-1

Atomics International
North American Rockwell

PURCHASE REQUISITION

SERIAL: MX13070

BUYER NAME: F — T. J. Bales — MO 3 DAY 22 YR 1

DEPT	LEDGER	ORDER NO		SUB ACCT.
131	24971	01757	A	35420
			B	(35420)
			C	
			D	

DELIVER TO: DEPT. 737 LOC C BLDG. 001 ROOM NO. 117-10 — Wm. [illegible] — 1

PROPERTY REVIEWER

ITEMS CODED NUMERIC IN CL. BOX HAVE BEEN SCREENED – ARE NOT AVAILABLE

ISSUE TO SUPPLIER CODE & SMALL BUS.: 17

PHRASE NOS.: 56

SHIP TO: 2

RATE % NET .050 — E.O.M. 10 d

SUPPLIER NAME: Gear Supply & Broaching

IN PERSON / LETTER / PHONE / WIRE: P — 3 22 1 — YOUR SALESMAN: Jack Sartore

GOVERNMENT CONTRACT NO: AT(04-3)-710 DC-82

STREET ADDRESS: 10422 Stanford Avenue

F.O.B.: Y

CITY & STATE: Garden Grove, California 92640

ATTACHMENTS: TT 2 Code 81-1

ADD TO BOXES NOTED

SHIP VIA: S Buyer's Truck

LINE	REQ ITEM	P.O. ITEM	QUANTITY	UNIT OF MEASURE	UNIT PRICE	DESCRIPTION	SHIPPING DATE	TOTAL
A	1	1	50	each	15.00 each	Finned cladding tube in accordance with Buyer's drawing number SK-11427 and specification number ST0115NA0019 NOTE A: Buyer to furnish 50 each Incoloy 800 tube blanks, .640 inch OD by .540 inch ID by 24 inches long. NOTE B: Buyer to furnish arbor, ~~xx~~ follower rest and hob; reference drawing number SK-11388. NOTE C: Seller to furnish, with shipment of Item 1 above, certification that only Buyer furnished material was used in the fabrication of Item 1 above.	30 days ARO	

... THAT BUYER ... PARTS. ...

SPECIAL NOTES, PLANNED USE, SUGGESTED SUPPLIERS, ETC.– IF THIS IS A CHANGE REQUEST, EXPLAIN THE KIND OF CHANGE AND SHOW THE AMOUNT OF INCREASE OR DECREASE IN ESTIMATED DOLLARS.

Gear Supply & Broach.
Garden Grove

Grow Gear
Burbank

Finished 3-26-71
[illegible] HANDS

DATE REQUIRED: 3 1 71 — REQUESTED BY: Armstrong / Schmidt — DEPT–GRP: 714-42 — MAIL ADDRESS: NB13 — 2-11-71 — EXTENSION 1523

FUNDS: MATERIALS / PURCHASED LABOR & SERVICES [X] / TEST EQUIPMENT

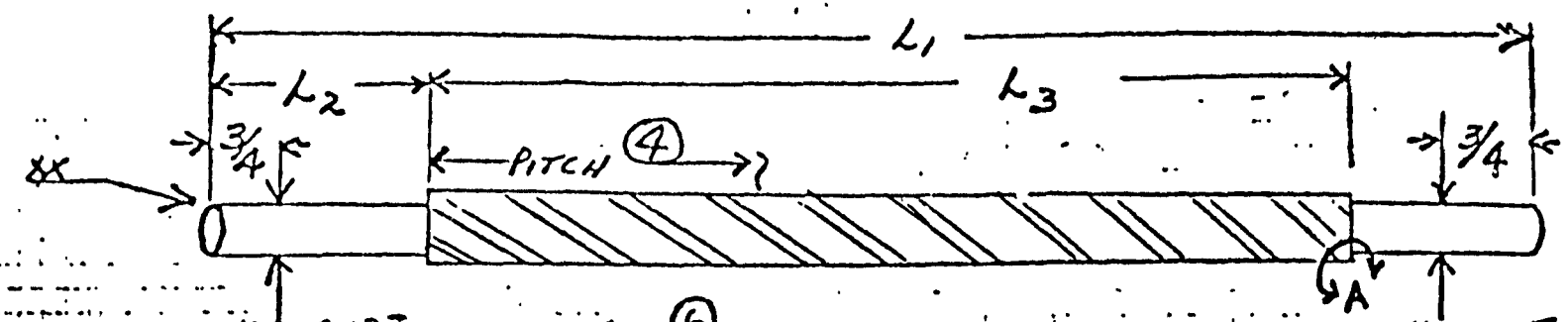
APPROVAL SIGNATURES

FINAL APPROVAL: 2 17 71

NO. TR-653-240-004 PAGE 10

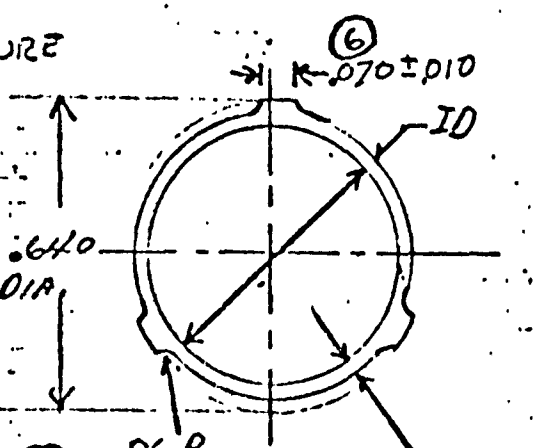
INSPECTION FORM FOR SNAP 8 FINNED TUBING

RE: DRAWING SK 11437



NOTES:

P/N 115000-



ID	DEPTH
S/NO END A	3/4"
B	3 1/4"
C	3/4"
O/P S/NO END D	3 1/4"

SURFACE FINISH	END	TOP OF FINS	BETWEEN FINS	END
	25 RMS	65 RMS	200 RMS	25 RMS

TUBE NUMBER	L1	L2	L3	PITCH (4)	RAD (5)	ID A 3/4" S/NO END	ID B 3/4"	ID C 3/4"	ID D 3/4"	FIN WIDTH (6)	RAD (7)	
DRAWING REQUIREMENTS →												
XX	21.00	2.00	16.50	5.50	.06"	← .540 ± .001				.070±.010	.06	
F-100	20.985"	1.950"	16.500	5.585"	.060	.5395"	.5394"	.5396"	.5394"	.074"	.060	
F-101	21.005"	1.955	16.550	5.587		.5398"	.5395"	.5397"	.5395"	.072"		
F-102	21.004"	1.940	16.520	5.587		.5393"	.5393"	.5394	.5395"	.074"		
F-103	20.995"	1.955	16.540	5.589		.5395	.5393	.5393	.5392	.074"		
F-104	21.000"	1.954	16.530	5.585		.5397	.5395"	.5396	.5394"	.075"		
F-105	21.000	1.956	16.520	5.584		.5395	.5393"	.5395	.5394	.073"		
F-106	21.001"	1.954	16.530	5.588		.5393	.5395	.5395	.5394"	.074"		
F-107	21.001"	1.965	16.510	5.587		.5395	.5393	.5395	.5394"	.075"		
F-108	20.996	1.965	16.520	5.585		.5395	.5394	.5395	.5393"	.073"		
F-109	21.000"	1.960	16.520	5.587	.060	.5396	.5395	.5395	.5394	.074"	.060	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

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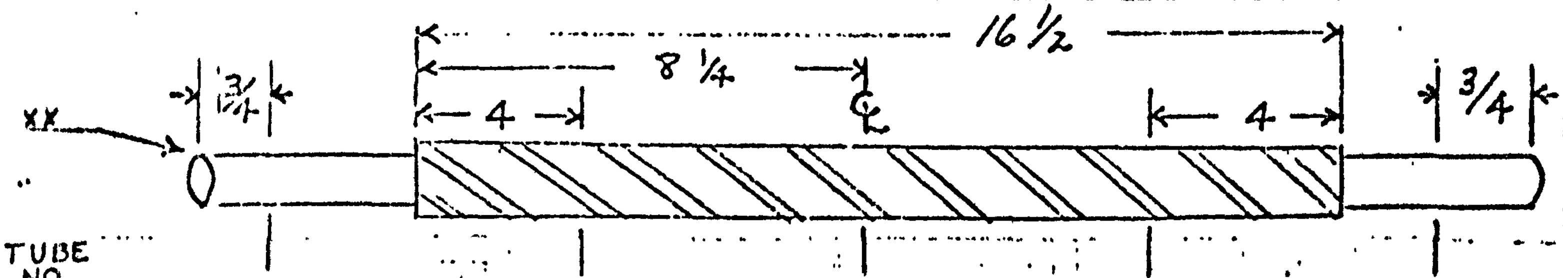
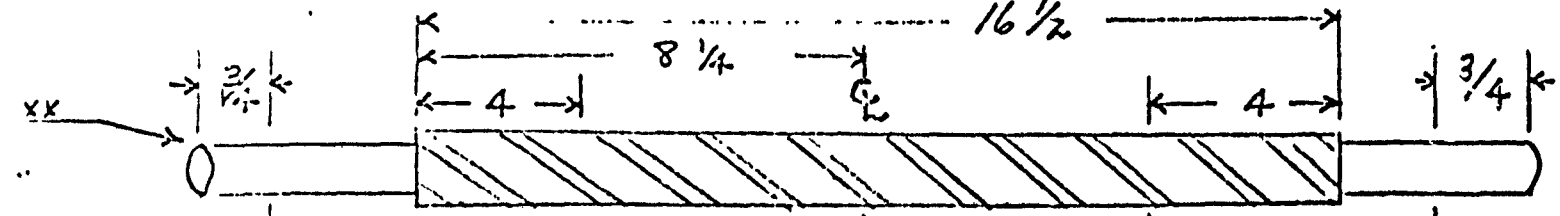
WALL THICKNESS · MEASUREMENTS



NOTES
PO# 115007c
overall avg = .0342"

TUBE NO.	Position	Top	Left	Right	Bottom	Summary
E-105 0°	1	0342	[illegible]	[illegible]	0340	.0342 AVG.
	2	0340	0343	0343	0344	.0346 MAX.
	3	0339	[illegible]	0344	0342	.0339 MIN.
	4	0342	[illegible]	[illegible]	0342	.0007 = R
	5	0343	0346	0340	0342	
E106 0°	1	0344	0344	[illegible]	0343	.0344 AVG.
	2	0346	0342	0346	0345	.0346 MAX.
	3	0342	0344	0342	0344	.0340 MIN.
	4	0342	0344	0342	0344	.0006 = R
	5	0346	0344	0342	0340	
E107 0°	1	0346	0342	0340	0342	.0343 AVG.
	2	0344	0340	0341	0342	.0346 MAX.
	3	0344	0342	0345	0346	.0340 MIN.
	4	0344	0346	0343	0345	.0006 = R
	5	0343	0340	0344	0341	
E108 0°	1	0342	0340	0346	[illegible]	.0344 AVG.
	2	0343	0346	0345	0346	.0348 MAX.
	3	0344	0346	0346	0346	.0338 MIN.
	4	0344	0346	0346	0344	.0010 = R
	5	0339	0342	0338	0340	
E109 0°	1	0340	0338	0342	0340	.0343 AVG.
	2	0342	0344	0344	0344	.0346 MAX.
	3	0343	0344	0344	0344	.0338 MIN.
	4	0346	0344	0342	0344	.0008 = R
	5	0342	0345	0340	0342	

WALL THICKNESS MEASUREMENTS



NOTES
PO#115007C
overall avg. = .0342" (FOR 10 TUBES)

TUBE NO.	10°	45°	90°	135°	170°		
F-100	0°	0344	0350	0346	0342	0346	.0344 AVG.
							.0350 MAX.
							.0336 MIN.
							.0014 = R
F-101	0°	0342	0344	0333	0334	0342	.0336 AVG.
							.0344 MAX.
							.0332 MIN.
							.0012 = R
F-102	0°	0346	0340	0338	0340	0346	.0341 AVG.
							.0346 MAX.
							.0335 MIN.
							.0008 = R
F-103	0°	0343	0342	0340	0340	0343	.0341 AVG.
							.0344 MAX.
							.0339 MIN.
							.0005 = R
F-104	0°	0343	0343	0346	0344	0339	.0342 AVG.
							.0346 MAX.
							.0338 MIN.
							.0008 = R

P.O. #1150070

WALL THICKNESS
SNAP 8 TUBES

Tube No.	End $\bar{X}$	Hobbed Section $\bar{X}$	$\bar{X}$	$\bar{X}$	End $\bar{X}$
100	.0341	.0343	.0346	.0348	.0343
101	.0342	.0336	.0334	.0335	.0341
102	.0342	.0340	.0340	.0342	.0342
103	.0340	.0341	.0341	.0342	.0341
104	.0339	.0344	.0345	.0342	.0341
105	.0341	.0342	.0341	.0342	.0343
106	.0345	.0344	.0343	.0343	.0343
107	.0343	.0342	.0344	.0344	.0342
108	.0343	.0347	.0345	.0345	.0340
109	.0340	.0343	.0344	.0344	.0342
Avg. ($\bar{X}$)	.0342	.0342	.0342	.0343	.0342

DATA SHEET

INCONEL FINNED TUBES UNBENT

5-26-71

TUBE NUMBER	DIMENSION (INCH) MARKED END	DIMENSION (INCH) UNMARKED END							
F150	.0023	.0002							
101	.0006	.0004							
102	.0010	.0010							
103	.0013	.0015							
104	.0012	.0015							
105	.0012	.0015							
106	.0015	.0015							
107	.0020	.0015							
108	.0030	.0030							
109	.0012	.0012							

DATA SHEET — TIR — INCOLOY 32 mil Finned TUBES (AS REC'D)

No.		100 in Chord TIR		No.	TIR.		No.		TIR
100		.005		119	.004		138		.003
101		.004		120	.002		139		.002
102		.003		121	.003		140		.004
103		.002		122	.003		141		.002
104		.003		123	.002		142		.003
105		.003		124	.002		143		.002
106		.004		125	.007		144		.006
107		.002		126	.005		145		.003
108		.002		127	.001		146		.002
109		.002		128	.002		147		.004
110		.002		129	.003		148		.004
111		.002		130			149		.003
112		.001		131	.005		150		.003
113		.002		132	.002				
114		.002		133	.008				
115		002		134	.003				
116		.001		135	.004				
117		.003		136	002				
118		.001		137	.003				

June 8, 11

DISTRIBUTION

FORM 712 E REV 10 67

IDR 05604

1 ART NO	2 CL	3. PART NAME	4. PO/MPO NO
		FINNED CLADDING TUBING	115-0070

5 PREVIOUS IDRS	6 MODEL/PROGRAM	7. GO NO.	8. SUB-ACCT. NO.	9. SUPPLIER OR DEPT.	PAGE 1 OF 1
		7759	35420	GEAR SUPPLY & BROACHING	

10 NO. PCS	11. SERIAL/LOT/HEAT/BATCH NO.	12. % COMP.	13. INSPECTOR	14. DATE
4	F-100 THRU F-109	90	A. E. Cottrill	5/24/71

15 NO.	16 REQUIREMENT	17 DISCREPANCY — WHICH	18. DISPOSITION
(1)	DWG REQ SK-11427 WALL THICKNESS .132" +.002" −.000	(1) TEN TUBES CHECKED. MAX .6350" MIN .0332" (SEE ATTACHED DATA SHEET)	I Com 1, 2 & 3 USE ALL MATERIAL AS IS. THESE TUBES ARE FOR PROCESS DEVELOPMENT & TESTING WHERE THESE DIMENSIONAL DISCREPANCIES ARE CONSIDERED MINOR.
(2)	THREE SPIRAL FIN PITCH 5.50" ±.03"	(2) PITCH MAX 5.589" MIN 5.585" SEE ATTACHED DATA SHEET.	
(3)	UNDER CUT NOT PERMISSIBLE	(3) UNDER CUT S/N END .003" MAX. .001" MIN CPP END. .003" MAX. .001" MIN. SEE ATTACHED DATA SHEET.	

Q C. ACTION COMPLETE

19. MATERIAL REVIEW ENGINEER DATE	20. ENGINEER DATE	21. DATE	22.	YES	NO	NOTED	23.
5/24/71	5/24/71	5/24/71	RESTRICTED END USE	☐	☒	☐	ASSIGNED 23-M-1 NO.
			NEXT ASS'Y AFFECTED	☐	☒	☐	ASSIGNED EO NO.

ATOMICS INTERNATIONAL — MR ENGINEERING COPY — COPY 1 — INSPECTION DISCREPANCY REPORT

GA-653-240-004
PAGE 17

Internal Letter

Date	April 30, 1971	No.	
TO	D.C. Campbell	FROM	F.C. Schrag
Address	737-72 1345	Address	737-72 1345
		Phone	1313

Subject: Trip Report to Gear Supply and Ultrasonic Distributing Co.

April 28, 1971, Matt Moessler and myself visited the subject company to discuss the SNAP fin cladding work. Our contacts with Gear Supply were Jack Santore and Roy Jenkins.

Gear Supply Co. has completed hobbing 50 Incoloy cladding tubes, which we were able to examine. The surface finish for these tubes appears excellent and the dimensions appear to be within specification. The tube wall thickness is running approximately .034 inch. Our wall thickness specification requirement is .032 + .002, - .000 inch. We measured the pitch on several of the cladding tubes. The pitch is running a little out of spec. That is, the pitch spec. requirement is 5.50 ± .030 inch and the tube pitch is running approximately 5.8 inches. We pointed this out to Roy Jenkins and he agreed the pitch was a little heavy. I told Roy that for these particular tubes, we would probably accept the out of spec condition, but the hydraulic test rods had to meet the specification pitch. I explained the need for pitch control on the hydraulic test rods was because of the effect it had on the flow characteristics.

They attempted to machine the ends of one sample tube with the hobbing tool in order to achieve the required fin relief. Such machining was done using the hob tool rotating out of synchronization. The surface finish caused by this technique was extremely rough and unacceptable. We did not see this particular part before it had been reworked by grinding. It appears that this new machining technique for the ends is unacceptable.

Currently, Gear Supply Co. is setting up their hob machine for the simulated fuel rods for hydraulic testing. These rods will be similar in configuration and diameter to the most recent design of the fuel element. Therefore, the machine set up used for these hydro test rods should be applicable for future cladding tubes.

In conclusion, it is my opinion that this is a very [illegible] shop. Matt Moessler agreed with this conclusion. The hobbing operations are acceptable, but it is apparent there may be some problems in their machine set ups. They are probably losing a little money because

of trial and error set-up of the hobbing machine as opposed to calculating gear ratios. The machine operator appears competent and conscientious. If there are any questions in regard to this company or the quality of their work, please don't hesitate to call myself or Matt Moessler.

F. C. Schrag
Process Development
& Test Unit

/ap

cc: W.F. Dennison
D.T. McClelland
M. Moessler