914

RECORD COPY

~~SNPO-C~~

WANL-TME-1359

Westinghouse Astronuclear Laboratory

EVALUATION OF A PROCESS FOR MANUFACTURING

AS-DEPOSITED I. D. INSULATING SLEEVES

MASTER

RECORD COPY

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

WANL-TME-1359

EVALUATION OF A PROCESS FOR MANUFACTURING

AS-DEPOSITED I. D. INSULATING SLEEVES

APPROVED BY:

F. A. Reed
Manufacturing Development

J. S. Blay
January 1966

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

D. C. Goldberg, Mgr.
Structural Material and
Processes

INFORMATION CATEGORY

UNCLASSIFIED
3/1/66
Authorized Classifier Date

J. L. Koetting, Mgr.
Program Control and Services

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

TABLE OF CONTENTS

	<u>PAGE</u>
1. Abstract	1
2. Introduction	3
3. Conclusions	6
4. Recommendations	7
5. Manufacturing Development Program	8
6. Results	9
Part 1 Feasibility Test	9
Part 2 Furnace Run	10
Part 3 Evaluation of Furnace Run	11
Part 4 Evaluation of Machined Product	13
Part 5 Development of a Machining Procedure	15
7. Discussion	16

LIST OF FIGURES

	<u>PAGE</u>
Fig. 1 Visual Appearance of Insulating Sleeves Received in 1963	19
Fig. 2 Slightly Renucleated, Multi-Delaminated Microstructure of 1963 Insulating Sleeves	20
Fig. 3 Improve, Highly Renucleated Microstructure of Tubes Received in 1964	21
Fig. 4 Improved Highly Renucleated Machined Sleeves	22
Fig. 5 As-Deposited I. D. Finish Machined Insulating Sleeve	23
Fig. 6 Sleeve Profile Data	24
Fig. 7 Density of 228 Insulating Sleeves	25
Fig. 8 Concentricity Utilizing Graded Mandrel versus Standard Mandrel	26
Fig. 9 Maximum and Minimum Inside Diameter of As- Deposited I. D. Insulating Sleeves	27

LIST OF TABLES

		<u>PAGE</u>
Table 1	Inspection Report of 15 Graded Mandrel Machined Sleeves	28
Table 2	Pre-Production Run Rejects	29

ABSTRACT

Machined-all-over pyrolytic graphite insulating sleeves have been very difficult to manufacture to WANL requirements. Substantial improvements have been realized in the quality, primarily by controlling the type of microstructure and the uniformity of deposition thickness. However, many of the resulting sleeves were still not entirely satisfactory because of excessive spalling and/or intersecting delaminations.

A most satisfactory evaluation was completed of a new concept manufacturing process for producing insulating sleeves of improved physical integrity. The process consisted of vapor depositing the pyrolytic graphite to the inside diameter requirements of the drawing, and machining the O. D. utilizing custom fitted arbors.

A supplier (Super Temp Corporation) on his own initiative, conducted a test, using twelve 0.2430" diameter graphite mandrels, to evaluate the feasibility of vapor depositing I. D.'s to $0.245" \begin{smallmatrix} +.005" \\ -.000" \end{smallmatrix}$ drawing dimension. No spalling or intersecting delaminations on the I. D. were observed, but seven of the tubes were out of the I. D. tolerance. An inside diameter of $.246" \begin{smallmatrix} +.004" \\ -.000" \end{smallmatrix}$ for as deposited I. D. sleeves was acceptable to Mechanical Design, making the process appear to be economically feasible.

A pre-production run consisting of 312 $0.2420" \pm .0005"$ diameter fine grain graphite mandrels was made for evaluating the process for vapor depositing I. D.'s to $.246" \pm .004"$. No spalling or intersecting delaminations of the I. D. was observed. There was a significant improvement in the physical integrity of the O. D. Only 20% of the sleeves met the drawing concentricity requirement of .006" maximum TIR.

An O.D. machining procedure, the utilization of custom fitted mandrels, was developed which produced sleeves to the concentricity requirement.

It was concluded that the I.D. deposited tube, machined by the custom fitted mandrel procedure resulted in improved quality insulating sleeves with a product yield at least the equal of the machined-all-over sleeve. Drawing 946C969 was created for the procurement of as deposited I.D. insulating sleeve hardware.

INTRODUCTION

Anisotropy, the key to pyrolytic graphite's unique thermal and mechanical properties, is also the cause of delaminations in curved shapes, which when intersected by a machined surface, are a major problem in the manufacture of insulating sleeves. These intersections which occur on both the O.D. and I.D. of most machined sleeves, seriously reduce the physical integrity of the component, resulting in localized areas of missing material. These spalled areas are prone to further flaking or peeling during inspection, assembly, and possibly operation.

Pyrolytic graphite is produced in a vacuum furnace by decomposing a carbonaceous gas on a pre-formed mandrel at about 4000°F. The process results in a graphitic material which is characterized by strong anisotropic properties. This is caused by the tendency of the individual crystallites to align themselves with their "c" axes to the surface of deposition. In the "a-b" plane, which is parallel to the mandrel surface, the carbon atoms are bonded to carbon atoms in parallel layers. In this plane, the material is exceptionally strong, is an excellent thermal conductor, and has a low coefficient of thermal expansion. Perpendicularly to the mandrel surface, the layers are held together by weak atomic bonding forces, which accounts for the material's excellent "c" direction thermal insulating characteristics, low tensile strength, and high coefficient of thermal expansion.

In the manufacture of insulating sleeves, the spalling problem is related to the "c" direction low strength and the directional difference in the coefficients of thermal expansion. In the "c" direction, the material contracts about 20 times greater on cool down from the deposition temperature than it does in the "a-b" direction. In a closed configuration such as the insulating sleeve; this anisotropy introduces extremely high residual stresses because of the incompatibility of the shrinkages in the two directions. At a wall thickness to radius (t/r)

ratio of above about .05, the residual stresses generated, approach the low "c" direction strength of the material. For tubes, from which insulating sleeves are manufactured, the t/r is in the vicinity of .55. Since the stresses exceed the "c" direction strength on cool down, the wall delaminates into thin concentric shells. This phenonoma acts as a stress relief as the material seeks the more favorable t/r of .05.

Perfectly aligned delaminations with a machined surface in a sleeve would not be a problem in manufacturing, but as deposition proceeds, the basal planes are progressively re-oriented. They are concentric and parallel to the first deposited surface, and also, to the last deposited surface. Initially, the typical out of furnace product was a highly delaminated, lowly nucleated tube, with a .005" to .015" per inch taper along its length looking like a minature baseball bat, bowed .003" to .005" and out of round up to .025". The machining of this delaminated furnace product invariably intersected O.D. and I.D. delaminations. This resulted in massive spalled areas with up to 1/2 of a surface missing, and depths of to .006". Adjacent to these areas because of the continuation of the delamination, the sleeve was conducive to further flaking during subsequent handling. See Figures 1 and 2.

Substantial improvement in the quality of sleeves has been realized by the combination of improving the tube profile (taper and ovality) and the deposition of a uniform, highly renucleated microstructure. These tubes have had a uniform dull gray appearance indicative of this fine grain interlocking microstructure, and the number of delaminations was greatly reduced. (See Fig. 3). The machined product which because of the reduced number of delaminations was high in density, could not easily be picked apart with the fingernail or destroyed by O.D. and I.D. bristle brushing. There was a significant reduction in the massiveness and frequency of the spalled areas. (See Fig. 4). However, some of the sleeves were still not satisfactory, some were marginal, and rejections for spalling still occurred at the suppliers and at WANL.

Further improvement appeared possible. As deposited, a delamination rarely intersects an O.D. or I.D. surface of a tube. Only when they intersect with a machined surface is a problem created. An as deposited I.D. insulating sleeve, one vapor deposited on a mandrel calculated to yield an I.D. to the drawing dimension appeared to be feasible. In this manner the detrimental I. D. spalling should be totally eliminated, and possibly an improved O. D. might result because of an improved parallelism of the outer delaminations with the machined surface.

CONCLUSIONS

Insulating sleeves with the inside diameter vapor deposited to size, are manufacturable to tolerances acceptable to mechanical design. The process, depositing the pyrolytic graphite on $.2420" \pm .0005"$ diameter fine grain graphite mandrels, and machining the O.D. using I.D. custom fitted arbors, resulted in a major improvement in the physical integrity of the sleeves. There was no spalled areas on the inside diameter, and only 3% had I.D. breakthroughs. Six percent of the sleeves had O.D. spalling, the depth and area of which was minor in nature.

The economics of the process appear to be about the same as the machined-all-over process. Furnace mandrel cost, because they are fine grain graphite and precision machined, will be slightly higher. The graded mandrel, custom fitted arbor machining procedure for maintaining concentricity will slightly increase costs. But both of these items should be offset by the anticipated increase in the yield of sleeves per furnace. Since unit price in the pyrolytic graphite industry is inversely related to yield, no increase in price for this improved quality insulating sleeve is anticipated.

RECOMMENDATIONS

It is recommended that:

1. As-Deposited I. D. insulating sleeves be used in future reactor builds.
2. Process improvements should be encouraged for further improving the quality and product yield. In particular, supplier process improvement is required for reducing in-house rejections for sooting and microstructure.
3. An evaluation be conducted of the interrupted deposition process for obtaining further improvement in both quality and cost.

MANUFACTURING DEVELOPMENT PROGRAM

The program conducted on a best effort basis consisted of the following five parts:

- Part 1 Feasibility test conducted by a supplier.
- Part 2 Deposition of one production size furnace load of tubes deposited on $.2420" \pm .0005"$ diameter mandrels.
- Part 3 Evaluation of the furnace product.
- Part 4 Evaluation of sleeves machined from those tubes acceptable for further processing.
- Part 5 Development of an "as deposited I. D. sleeve machining procedure".

RESULTS

PART 1 - FEASIBILITY TEST

A test was conducted by the Super Temp Corporation to evaluate the feasibility of vapor depositing I.D.'s to the $0.245'' \begin{smallmatrix} + .005'' \\ - .000 \end{smallmatrix}$ dimension of Drawing 246C055. In a production furnace run for producing the machined-all-over sleeve, twelve 0.2430" diameter mandrels, that calculated to yield an I.D. to the above dimension, were spotted in four in-line vertical stations. The data generated by this test, though made available for evaluation, were considered company proprietary, since the test was performed at their expense. In summary, seven of the twelve sleeves I.D.'s were up to .004" out of tolerance. There was no spalling or intersecting delaminations on the I.D. of the twelve sleeves. The O.D. appeared to be somewhat improved.

Mechanical Design approved a $0.246 \pm .004$ dimension for the I.D. of the sleeve. This made it appear that a 0.2420" diameter mandrel would be well suited for evaluating this concept process.

PART 2 - FURNACE RUN No. 42-165

The tubes were manufactured on Purchase Order 43128 by the Super Temp Corporation, using their standard insulating sleeve process, vapor depositing at $2200^{\circ}\text{C} \pm 25^{\circ}\text{C}$ in a four foot diameter induction heated vacuum furnace. The susceptor size (heating zone) was 17" diameter x 34" long. Processing gases were hydrogen, natural gas, and nitrogen. The thermal cycle, pressures and gas flows, are considered proprietary information. Deposition rate is targeted at about 2 mils/hour.

The furnace set up consisted of 312 fine grain graphite mandrels, .2430" $\pm$.0005" diameter by 5" long supported in a vertical position. These were separated into four levels, identified as tiers 1, 2, 3, and 4. Tiers 1, 2, and 3 contained 72 mandrels each, tier four had 96. Each tier consisted of six stations, located at 60° intervals around the periphery of the heating zone. Each station of tiers 1, 2, and 3 had three rows of mandrels spaced 1" apart, and staggered vertically 2"; tier 4 had four rows arranged similarly.

PART 3 - EVALUATION OF FURNACE RUN No. 42-165

The furnace run resulted in 312 pyrolytic graphite tubes. Forty-eight (48) of the tubes from locations 4C and 4D, the lower extremity of the furnace, had a black shiny surface, indicative of a highly delaminated, lowly renucleated, columnar type of microstructure. Experience has established that this type of microstructure, illustrated in Fig. 2, does not machine into an acceptable insulating sleeve, and they were not further processed. Eliminating the mandrels from these positions in the furnace does not eliminate the yield of this undesirable product. In this process it appears that the first deposited tubes in some manner catalyze the gas reaction for producing down stream the fine grain product. They are a necessary but non-productive part of the furnace set up. Two tubes, one each from locations 1A and 4B were sent to metallography for microstructural analysis per the specification. The remaining 262 tubes were inspected. Results were as follows:

Dimensional Inspection

No I.D. inspection was performed at this time. Previous experience has established that O.D. stock removal alters the stress pattern to the extent that the I.D. dimensionally is different after machining. There was sufficient stock on the O.D. of the 262 tubes for clean up to the drawing dimension. Deposition profile throughout the furnace load was considerably improved over a prior evaluated furnace run as shown in Fig. 6.

Visual Appearance

All of the tubes had a uniform dull gray appearance. No delaminations intersected either an O.D. or I.D. surface. Twenty-three (23) tubes had excessive sooting, and eleven had large nodules in excess of that permitted. These thirty-four tubes were not further processed at this time. The I.D. of the tubes had a smooth highly reflective appearance and no mandrel pull out areas were observed.

Microstructure

The microstructure of the two tubes selected from the vertical extremities of the furnace run was uniform and highly renucleated, meeting the requirements of PS294601. They contained three and four delaminations respectively, appearing identical to that illustrated in Fig. 5C and 5D.

The 228 tubes acceptable for further processing were finish machined by the following approved machined-all-over insulating procedure as follows:

1. I.D. brushed by the approved WANL procedure.
2. O.D. ground to size on a .2420 diameter steel arbor, three passes minimum.
3. Face off one end to clean up only.
4. Cut to length.

PART 4 - EVALUATION OF MACHINED PRODUCT

Visual

The O.D. of the sleeves had a uniform dull gray appearance, both within a sleeve and from sleeve to sleeve. Thirty-two (32) sleeves had minor spalling, in most cases about .001" deep and not in excess of $1/4" \times 1/2"$. Five sleeves had spalling in excess of the drawing requirement. No intersecting delaminations were observed on the I.D. of any sleeve, and there was no evidence of spalling, excepting on twelve sleeves which had I.D. breakthroughs. Typical O.D. and I.D. surface appearances are illustrated in Figures 5A and 5B. No sooting was observed and no nodules or nodule clusters were in excess of requirements.

Density

Ninty-two percent (92%) of the 228 sleeves met the 2.00gms/cc minimum apparent density of the specification, and none were below the 1.90 gm/cc requirement of Drawing 946C969. The minimum density of this batch of sleeves was 1.96. The density frequency of the 228 sleeves is illustrated in Fig. 7. The highest density product, that with minimal delaminations came from the upper tier of the furnace load, and in this zone, none were below 2.00 gm/cc. At each lower level of deposition, the density decreased, and at tier No. 4, 12% were below the 2.00 gm/cc requirement, as illustrated in Fig. 7.

Dimensional

The outside diameter of 227 sleeves met the drawing requirement of $.357 \pm .002$, one sleeve having been mis-machined to .354".

Sixty-eight percent (68%) of the I.D.'s met the original $.245 \pm .005$ with local variations not to exceed .254" for a maximum of $1/3$ the sleeve length. A massive 97% (221 parts) met Mechanical Design's revised requirements of $.246 \pm .004$ ", local variations not to exceed .252" for a maximum of $1/3$ the length. The I.D. inspection data is shown in Fig. 8.

224 sleeves met the .003" maximum $\perp$ requirement.

203 sleeves were within the .005" maximum bow.

Only 52 of the 228 sleeves met the .006 maximum TIR $\odot$ of the drawing.

See Fig. 9.

PART 5 - DEVELOPMENT OF A MACHINING PROCEDURE FOR MAINTAINING CONCENTRICITY

Purchase Order 47924 was placed for the development of an as-deposited I. D. machining procedure for yielding sleeves to all of the requirements of Drawing 946C696.

The fifteen (15) tubes, held up for oversize nodules and/or excessive sooting were O. D. machined by custom fitting .2420", .2440", .2460" and .2480" diameter steel mandrels. These mandrels were individually fitted to the tube for minimal clearance. The O. D. was then ground to size, three passes minimum, and cut to length.

All fifteen (15) sleeves met the drawing requirements for O. D., concentricity, bow, and perpendicularity. There was no evidence of spalling on fourteen of the parts, one having minor spalling. There was no spalling or delamination breakthrough on the I. D. Each sleeve had either sooting or nodules in excess of that permitted, as expected. Detailed inspection data is shown in Table 1.

DISCUSSION

Furnace run 42-165, in conjunction with the graded mandrel machining procedure, successfully demonstrated that improved physical integrity insulating sleeves can be manufactured economically by the as-deposited I.D. process.

The furnace run was the supplier's standard process for vapor depositing pyrolytic graphite tubes for producing, WANL insulating sleeves. The process parameters, time, temperature, gas composition, gas flows, pressure, thermal cycling, and mandrel positioning, had been developed by the supplier on his own initiative to meet WANL requirements of a high density, highly renucleated microstructure per PDS30014. The only deviation in this run from previous runs was the use of a fine grain, molded graphite mandrel, centerless ground to $.2420 \pm .0005$ " diameter.

The furnace product yield of 75%, was normal for the process. As illustrated in Table 2, Items 1 and 2, 15% had the black, shiny, lowly nucleated, highly delaminated microstructure, and 11% had sooting in excess of requirements. The lowly nucleated material invariably is the first deposited product at the lowest extremity of the deposition zone adjacent to the entering gases. Sooting, though minimized, generally is generated in the upper extremity of the deposition zone near the exiting gases. This appears to be inherent to all present day fine grain processing techniques. The process parameters for producing highly regenerative material are very precise and the deposition band very narrow. The entering gases are apparently at the upper spectrum of the slightly nucleated product, and the reaction equilibrium of the exiting gases is shifted during deposition to the opposite end of the deposition spectrum where sooting occurs. The utilization of the fine grain graphite mandrels resulted in an excellent I.D. surface similar to a lapped finish, as illustrated in Fig. 5B.

For all categories, the percent rejects are similar to that the supplier had recently experienced in producing machined I.D. sleeves as shown below:

<u>Category</u>	<u>Furnace Run 42-165(%)</u>	<u>Supplier and WANL Experience (%)</u>
1. Microstructure	15	10
2. Sooting	11	15
3. I.D. Breakthroughs	4	6
4. Concentricity	0	2
5. I.D. Oversize	2	0
6. Spalling O.D.	2	4
7. Spalling I.D.	0	4

The I.D. and the O.D. were resistant to deterioration by the WANL brushing procedure. Where O.D. spalling did occur, the surface was not easily further picked apart with a probe, and they were highly resistant to continued flaking. It appeared that an improvement in the alignment of delaminations with the O.D. machined surface had resulted.

This evaluation resulted in the creation of Drawing 946C969 for the procurement of the as-deposited I.D. sleeve.

A further improvement in quality, if required, may be possible by the newly conceived controlled delamination process, with possibly a cost improvement bonus. This process consists of interrupting the deposition process at pre-determined intervals which results in a structure containing pre-placed concentric delaminations. Conceivably for insulating sleeves, the process would be interrupted four or five times for the highly renucleated material at about .015" increments across the wall. By vapor depositing material in this manner the residuals stresses of the concentric rings should not exceed the tensile strength of the material, resulting in tubes with pre-placed delaminations and no micro-cracking.

In the continuous deposition process for shapes, the residual stresses generated on cool down, exceeds the tensile strength of the material randomly delaminating the material and in the process radial microcracks are formed as vividly illustrated in Fig. 2C. Apparently these radial microcracks act as heat sinks through which heat can leak and result in wide variations in thermal conductivity. It is alleged that no microcracking exists in the structure of material properly produced by the interrupted process which accounts for allegedly improved and more uniform insulating characteristics. In addition, it appears that the delaminations may be placed in a position that no I.D. breakthroughs might occur, and also in a position that would minimize their intersection with O.D. machined surfaces.

a. General O. D.
Appearance - IX

b. Longitudinal Section - IX

c. Longitudinal Section - 3X

Fig. 1 - Visual Appearance of Insulating Sleeves received in 1963.

a. I.D. Intersection with
Delamination - 25X

b. Transverse Section - 75X

c. Longitudinal Section - 75X

Fig. 2 - Slightly Renucleated, Multi-Delaminated Microstructure of 1963 Insulating Sleeves.

a. General Appearance IX

b. Highly Renucleated Microstructure -
Transverse Section - 75X

c. Reduced Delaminations in Highly
Renucleated Microstructure -
Longitudinal Section - 25X

d. Transverse Section showing Parallelism
of Delaminations with As-Deposited
Surfaces - 25X

Fig. 3 - Improved, Highly Renucleated Microstructure of Tubes received in 1964.

a. General Appearance - IX

b. Cross-Section of Delamination Intersecting Machined Surface - Transverse Section - 75X

c. Spalled Area caused by Intersection of Non-parallel Delamination with Machined Surface - Longitudinal Section - 25X

Fig. 4 - Improved Highly Renucleated Machined Sleeves

a. O. D. Appearance - 1X

b. I. D. Appearance - 1X

c. Longitudinal Section - 25X

d. Transverse Section - 25X

Fig. 5 - As-Deposited I. D. Finish Machined Insulating Sleeve

Figure 6 Sleeve Profile Data

Figure 7 Density of 228 Insulating Sleeves

Figure 8 Concentricity Utilizing Graded Versus Standard Mandrels

610791-3B

Figure 9 Maximum and Minimum Inside Diameters of as Deposited I.D. Insulating Sleeves

TABLE 1 - INSPECTION REPORT OF FIFTEEN GRADED MANDREL MACHINED SLEEVES

Sleeve No.	Density 2.00 min.	O. D. 355- 359	I. D. 242- 250	Length 4.00 + .005	T I R		Spalling	
					End	Opposite End	I. D.	O. D.
1	2.03	ok	ok	ok	.001	.003	none	none
2	2.06	ok	ok	ok	.005	.003	none	none
3	2.05	ok	ok	ok	.004	.003	none	none
4	2.02	ok	ok	ok	.006	.003	none	Chipped one end 1/8 x 1/16 x .002"
5	2.02	ok	ok	ok	.006	.003	none	none
6	2.01	ok	ok	ok	.002	.006	none	none
7	2.03	ok	ok	ok	.005	.004	none	Chipped one end 1/8 x 3/16 x .004"
8	2.04	ok	ok	ok	.006	.002	none	none
9	2.02	ok	ok	ok	.002	.004	none	Spalled 1/3 area x .002"
10	2.02	ok	ok	ok	.006	.003	none	none
11	2.00	ok	ok	ok	.001	.003	none	none
12	1.98	ok	.250	ok	.002	.006	none	none
13	2.01	ok	ok	ok	.006	.001	none	none
14	2.00	ok	ok	ok	.003	.005	I. D. Break- through	none
15	2.00	ok	ok	ok	.003	.003	none	none

NOTE 1 - Bow - less than .002" - all parts

NOTE 2 - $\perp$ - all parts within drawing requirement of .003.

TABLE 2 - PRE-PRODUCTION RUN REJECTS

<u>Category</u>	<u>Quantity</u>	<u>Percent</u>
1. Microstructure	48	15.4
2. Sooting	34	10.9
3. To lab for test	2	.6
4. Density	17	5.4
5. I.D. Breakthroughs	12	3.8
6. O.D. Undersize	1	.3
7. I.D. Oversize	7	2.3
8. <u>I</u>	4	1.3
9. Bow	25	8.0
10. Concentricity (Projected)	0	--
11. O.D. Spalling	<u>5</u>	1.6
TOTAL REJECTS- 155		49