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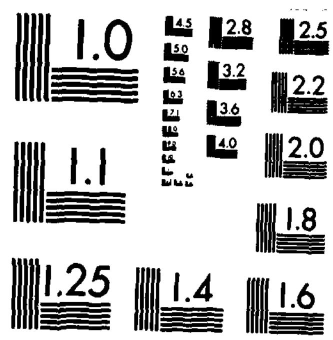

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Final Technical Report
December 1984

DOWNDRAW EXTRUSION OF ULE^{TM} GLASS

Corning Glass Works

P. M. Smith and C. E. Peters

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, NY 13441-5700

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This report documents an experiment to determine whether it is possible to extrude Ultra Low Expansion (ULE) silica glass. A heat cycle experiment was performed which demonstrated that the material could withstand the time/temperature cycle required in the appropriate chemical environments. Extrusion apparatus was then assembled, configured and tested. Two runs were made in which ULE was extruded. Although the results showed much scatter of the data, the mean properties of the extruded material were the same as for the control material, which suggests that with more process optimization, extrusion of ULE in sufficiently high quality for mirrors should be possible.

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TABLE OF CONTENTS

GLOSSARY OF TERMS AND ABBREVIATIONS

CTE	Coefficient of Thermal Expansion
I-100	"Inducto 100" Console Mounted Motor Generator Set
ULE^{TM}	Ultra Low Expansion Glass
Charge	Glass Loaded into Furnace For Remelting
Cyclops	Minolta Land "Cyclops" Hand Held Infrared Pyrometer
Pot Setting	Potentiometer Setting

1. INTRODUCTION

In September 1982 Corning submitted a proposal to Air Force Systems Commands Rome Air Development Center for conducting a program to evaluate the feasibility of remelting and drawing Code 7971 ULE^{TM} glass. This proposal was made as part of an effort by Corning to reduce the costs and lead times of lightweight mirror core components. ULE^{TM} glass struts produced by a downdraw process would reduce costs and manufacturing time through increased material utilization.

The first step in the downdraw program was to demonstrate by laboratory experiments, the basic feasibility of remelting code 7971 glass. The results of this experiment were presented in H.E. Hagy's report "Evaluation of Thermal Expansion and Viscosity Changes in ULE^{TM} Titanium Silicate Due to Thermal History Simulation of Remelt for Redraw", September 28, 1983. In November, 1983, after the experiment was completed and the results were reviewed by RADC, the program proceeded with the design and installation of a furnace system for remelting and drawing ULE^{TM} glass. In June, 1984 two trial runs were made and the drawn ULE^{TM} glass samples were measured to evaluate the effect of the process on the glass thermal expansion.

2. LAB TEST

2.1 Experiment Plan

A laboratory experiment simulating the conditions of remelting ULE^{TM} glass in the downdraw furnace system was to be conducted to determine the effect of remelting on CTE.

A piece of ULE^{TM} glass, shown to be homogeneous for CTE was to be selected for evaluation. One-half of the material would be remelted in a small induction furnace under conditions similar to those in the proposed downdraw furnace.

This material, after undergoing the time and temperature cycle would provide the center component of a sandwich seal. A sandwich seal consists of 3 layers of glass, a center component of unknown expansion and two outer components of known expansion. The outer two components would come from the unprocessed half of the original material. A photoelastic analysis (seal test) would provide data on any change in CTE. Remelted material would also be evaluated for change in thermal expansion by dilatometry. In addition strain and anneal points would be determined and compared with unprocessed material.

2.2 Apparatus

The glass remelting operation was conducted in the Developmental Melting Facility at Sullivan Park, Corning, N. Y.

An Inducto 30 console mounted motor generator set was used as the induction coil power supply. A concentric arrangement consisting of a fused silica outer sleeve, graphite felt, and carbon crucible/susceptor was used to simulate the conditions to be found in the full scale furnace.

CTE results are obtained with a Friedel polarimeter and with a dilatometer.

Strain point and anneal point are determined with a beam bending viscosimeter.

2.3 Procedure

A laboratory experiment was conducted to determine if remelting ULE™ glass effected the coefficient of thermal expansion. Three 2" dia. x 4" long cylindrical slugs were core drilled from a block of ULE™ glass 6" x 6" x 4". Each slug was heated in an induction furnace and held for 1/2 hour at 1650°C to simulate conditions for remelting and drawing. Following these remelting thermal cycles, all three slugs were annealed together using the standard anneal for ULE™.

A 1/8" x 3 7/8" x 1 7/8" piece was cut from each of the three slugs. Each of these pieces were fritted to two identical parts from the original block to form a symmetrical sandwich seal.

A 3/8" x 4" diameter rod was cut from each of the three slugs and from the original block. These pieces were used for determination of the CTE with the superdilatometer.

A 1/10" x 1/10" x 3" beam was cut from each of the three slugs and from the original block. These pieces were used to determine this annealing point and the strain point using beam bending viscometry.

2.4 Results

2.4.1 Symmetrical Sandwich Seal

Slug No.	Block Minus Slug (ppB/°C)
1	+0.36
2	+4.65
3	-0.90

2.4.2 Superdilatometer

Slug No.	Block Minus Slug (ppB/°C)
1	+ 2
2	+18
3	- 6

2.4.3 Beam Bending Viscometry

Slug No.	Annealing Point °C	Strain Point °C
1	1008	897
2	1008	898
3	1009	899
Original	1007	896

2.5 Conclusions

Evaluation of the results obtained with sandwich seals and the superdilatometer show no significant changes in thermal expansion are caused by the simulated remelt thermal cycle. Slug No. 2 does show a small expansion difference which could have existed prior to remelting.

The anneal point and strain point show no significant differences. This indicated that material composition and structure are unchanged. None of the results found in this laboratory simulation indicate that the CTE of ULE™ glass will change during a remelt process.

3. DEVELOPMENT PROGRAM

3.1 Development Plan

3.1.1 Objective

The objective of this project was to demonstrate the feasibility of drawing Code 7971 ULE™ glass by a process which can be used to make the core material for lightweight mirrors.

In order to accomplish this objective ULE™ glass would be remelted and approximately 100 feet would be drawn. Glass property measurements would be evaluated to determine the technical feasibility of the process.

3.1.2 Activities

As part of this feasibility demonstration, equipment that would be suitable for use during the process development trials would be developed. Engineering drawings of the downdraw system would be prepared including equipment design, facility layout and services. Materials would be specified and installation of the system would be completed. The equipment would be fully tested and evaluated prior to the start of the process development trials. The fundamental design of this equipment would be similar to that used in the past by Corning to manufacture fused quartz tubing.

3.1.3 Design Concept

This design concept uses a high frequency motor generator set to supply power to a furnace consisting of a water cooled induction coil surrounding an insulated cylindrical carbon susceptor. ULE™ glass in a carbon crucible located in the center of the furnace, would be heated to a point where it could be pulled through an appropriately sized orifice in the bottom of the crucible. This design concept is illustrated on p. 23, sec. 4.1

3.2 Equipment Procurement

3.2.1 Motor Generator

An Inducto 100 console mounted motor generator set was obtained from another Corning facility where it had been in storage since 1980. The Inducto 100 unit was manufactured by Inductotherm Corporation for Corning Glass Works in May 1965. It was used as the power source for a quartz crucible manufacturing operation in Corning, N.Y. from 1965 through 1980. The Inducto 100 unit contains the following items:

- Westinghouse High Frequency Motor Generator Serial No. 35-65.
    - Generator 100 KVA, 3000 cycle, 400/800 volts, single phase.

      Motor 150 h.p., 220/480 volts, 3 phase.
- High frequency water cooled capacitors for matching coil to power supply.
- Tap switches for impedance matching transformer and capacitor tuning.
- Meters for generator voltage, generator current, output kW, power factor, coil voltage, coil current.
- Variable autotransformer for setting field voltage excitation.
- Circuit fault monitor panel for cabinet water pressure, generator air temperature, starter interlock, generator overload, gas pressure,

clear .00066 weight % Ti_2O_3
dark .0264 weight % Ti_2O_3

Run 2 A plot of temperature versus time is given on p. 60, sec. 4.7. The plate averaged 60°C cooler than the glass as read by an optical pyrometer until 1525°C.

Glass temperature on top of the charge (read through the sight port with an optical pyrometer) was 165°C hotter than the glass temperature orifice at 1625°C. (p. 61, sec. 4.7.1). There was fairly good agreement between the optical pyrometer and the cyclops up to 1500°C. Throughout the run the cyclops averaged 27°C hotter than the optical pyrometer. (p. 62, sec. 4.7.2).

As seen in Run 1 when the generator voltage % is increased, the power (kilowatts) increases. This is illustrated on p. 63, sec. 4.7.3.

Product data is given on p. 64-66, sec. 4.7.4. The table lists information on sample number, sample time, weight, length, pull machine setting, diameter, attenuation and a product description.

A total of 21 lb or 68 feet of clear product was drawn. An additional 45 lb or 262 feet of other product was drawn from the furnace. 4 lb remained in the crucible at the end of the draw. 5 lb or 6.7% of the charge was unaccounted for. The average sample had a diameter of .534" and an attenuation of 3.4. Average mass throughput was 20 lb/hour. Throughout the pull, the pull rate was increased in order to determine the effect on the product. Increasing the potentiometer setting on the pull machine results in an increase to the inches per minute of draw as illustrated on p. 67, sec. 4.7.5. This rate increase was linear to a pot setting of 50%. As the product degraded, the rate leveled and then declined (at settings of 50, 60 and 70.) Values for the pull rate at each setting were obtained by averaging the rate obtained using two methods:

A. Periodically timing the product as it when opened. Other carbon components were reusable.

Run 2 Only 4 lb of glass remained in the crucible at shutdown. This 4 lb was dark and foamy. This crucible also had a crack, one smaller in magnitude than in run 1. The spacer ring and orifice was again plugged. Other components were reusable.

3.5.3 Results

Run 1 The ability to flow ULE™ was established. The glass had a working viscosity range when heated sufficiently.

This run demonstrated a need to reconfigure the muffle region to get more cooling. This was done for the next run by increasing the muffle plate ID from 5" to 7".

From the cane obtained during the run, the diameter of the product varied between .070" and .300" or an attenuation range of 2.5 to 10. The average product diameter was .136" or an attenuation of 5.5 (orifice diameter product diameter = attenuation, .75 .136 = 5.5). This demonstrated a need to increase the orifice diameter to 1 1/2" to 2". An orifice of 1 3/4" diameter was used for run 2.

Absolute radial CTE was read on chucks of glass cut from the clear glass remaining in the crucible at shutdown. Two readings of -5 ppb and + 2 ppb were obtained. This is comparable to the - 8 ppb to + 7 ppb radial reading range of the feedstock placed in the furnace, indicating that the heated and cooled clear glass is still ULE™.

Electron paramagnetic resonance (EPR) spectrum was run on two samples of the glass remaining in the crucible: one clear and one dark and foamy. In both samples reduced titanium (Ti^{+3}) was detected, but the dark sample had a concentration 40 times greater than the clear sample:

temperatures at several locations in the muffle region were recorded. These are given on p. 57, sec. 4.6.3

Run 2 Pull was established at 1650°C by fusing a quartz rod to the side of the plug and tugging. A pair of tongs was also used to help draw the glass to the rollers.

Glass was cut-off below the rollers by two operators - one would hold the cane in place while the second broke the product with a pair of hammers. Samples were labeled with a sequential number and a time at cut-off. Throughout the pull the pull machine rate was varied to determine the effect on the product. One and a half hours into the pull the product changed from clear cane to ware with a dark streak. As the run progressed the product quality degraded. (The pull is discussed further under "Results"). Total run time was 20.3 hours, including a 3.5 hour pull. Temperature profile in the muffle region of the furnace is given on p. 58, sec. 4.6.4.

D. Shutdown followed the procedure listed on p. 59, sec. 4.6.5.

E. Furnace Inspection After the furnace cooled, the water was shut off and the top plate was removed. Felt and carbon components were inspected for wear.

Run 1 Felt near the crucible top was stiff and had a ring of white around the spacer ring. Spacer ring was plugged with ash. Crucible cover looked good. Crucible was cracked at the base. Orifice hole was plugged with glass. The glass remaining in the crucible was dark and foamy. When wire sawed into sections the glass has swirls of blue streaks and bubbles through the body. The bottom 4" of thin glass was clear and had only a few streaks. The top 4" was foamy and bubbly. The furnace had a sulfur-like smell cyclops pyrometer was also used to gather temperature readings. Temperature of the glass and on the orifice plate was recorded. Log sheets for both runs are attached on p. 48-56, sec. 4.6.2.

The voltage percentage was increased to maintain the temperature heat-up schedule, resulting in a corresponding increase in kilowatts and a gradual decrease to the power factor. Water pressure was maintained at greater than or equal to 20 lb inlet. Inlet temperature was as delivered from the plant system, run 1 between 60° to 65°F and run 2 between 70° to 75°F. Outlet water temperatures increased as the power to the coil was increased, but was kept at less than or equal to 90°F by increasing the water flow to a hot component. Gas inlet pressure was set at 10 psi. Gas flows ran at 10 l/min. through the furnace run.

C. The Pull The "pull" refers to the period of time when glass is drawn from the furnace. The "plug" is the initial section of glass that appears in the orifice opening.

Run 1 At 1500°C (approximately 5 am on 6/6/84), glass could be seen slumping through the orifice. By 1650°C (8 am) glass appeared to be in a workable range, suitable for pulling. Attempts were made to start the pull by fusing a fused quartz rod to the plug and tugging on the rod to draw it through the pull machine rollers. A pull was established three times but could not be maintained. The furnace was shutdown with less than 3 feet of product draw. Total run time was 24.5 hours.

While glass could be drawn through the orifice, attenuation was so great in the muffle region that the product would break before a stabilized pull could be established. The glass that was drawn had a dark surface coating, believed to be the result of getting the furnace too hot. Prior to shutdown,

21. Insert carbon gas pin into top plate plug.
22. Set o-ring on top plate and seat plug on top.
23. Clamp plug in place.
24. Connect water lines.
25. Connect gas lines.

Run 1 was configured with a 3/4" diameter orifice and a 5" inner diameter muffle plate. Run 2 was configured with a 1 3/4" diameter orifice and a 7" inner diameter muffle plate.

E. Glass Loading After removing the plastic and tissue paper from the cleaned feedstock glass, the disks were lowered into the crucible and centered onto the orifice plate using hand vacuum cups. Load order, charge weight and charge height are given on p. 42, sec. 4.5.

3.5.2 Procedures

A. Start Up Procedure is given on page 46, sec. 4.6

B. Furnace Run Run 1 and Run 2 followed a 20.5 hour and 16 hour heat up cycle to 1650°C, respectively. Cycles are listed on p. 47, sec. 4.6.1. Run 1 used nitrogen as a purge gas. Run 2 used nitrogen to 600°C, then switched over to argon (at pressure of 10 psi and flows of 10 l/min). The following parameters were monitored and recorded at 15 minute intervals through the heat-up cycle: furnace temperature, generator voltage percentage, kilowatts, power factor rating, inlet water pressure and temperature, outlet water temperatures (for plates, generator, coil and electrical components), inert gas pressure and flow. Temperature was monitored to 800°C using a type K thermocouple inserted through the orifice and touching the base of the glass charge. At 800°C the thermocouple was removed and temperature was monitored with an optical pyrometer. During run 2 a Land

D. Furnace Assembly

The furnace assembly procedure is as follows:

1. Install top support plate on tower.
2. Set coil on bottom plate.
3. Wrap susceptor with graphite felt.
4. Lower silica sleeve onto susceptor assembly.
5. Place gas distribution tube on support plate.
6. Place gasket on bottom support plate.
7. Lower susceptor and silica sleeve onto gasket and support plate.
8. Place gas distribution tube, alumina sleeve, muffle plate, support ring, orifice plate on middle support plate.
9. Insert assembly into bottom of furnace and bolt middle support plate to top support plate.
10. Lower crucible into furnace and seat on orifice plate.
11. Place inner alumina muffle and gas distribution tube on bottom support plate.
12. Insert assembly into bottom of furnace and bolt bottom support plate to middle support plate.
13. Vacuum furnace to remove loose carbon, etc.
14. Place crucible cover on top of susceptor.
15. Cut felt and layer on top of crucible cover to top of furnace.
16. Place gasket on top of silica sleeve.
17. Install support rods from bottom plate.
18. Install bushings on support rods.
19. Set top plate onto support rods -- seat against gasket.
20. Install isolation bushings and bolt top plate into place.

34-109. For each run three 9.5" diameter disks were prepared using the following steps:

1. Hex oversize per layout lines.

2. Circle to specified diameter (9.5 ± 1/8").

3. Skim top and bottom with 320 grit to flat and parallel. Dimension to maximum, but less than 5.1".

4. Hand-bevel to break sharp edges.

Actual dimensions and finished weights are given on p. 42, sec. 4.5 for runs 1 and 2.

B. CTE Radial absolute coefficient of thermal expansion was read at one inch intervals on three axes, 120° apart for each feed stock disk. Axial absolute expansion was taken at 1/4" intervals from a standard block corresponding to the same boule (and of the same thickness) as the feedstock for each run. See p. 43, sec. 4.5.1. CTE data is given on p. 44 and 45, sec. 4.5.2.

C. Cleaning Feedstock glass was thoroughly cleaned to prevent devitrification from oils and other surface contamination using the following procedure:

1. Wipe with xylene.
2. Rinse with deionized water.
3. Scrub with powdered detergent and deionized water.
4. Rinse with deionized water.
5. Swab with muriatic acid. Let acid set for 10 minutes.
6. Rinse with deionized water.
7. Wipe dry with paper towel. (Handle clean ware with white cotton gloves).
8. Wrap clean ware in tissue, then plastic. Seal plastic with masking tape.

following parameters were monitored and recorded at 15 minute intervals through the heat up cycle: furnace temperature, generator voltage percent, output kilowatts, power factor, inlet water pressure and temperature, outlet water temperatures, purge gas pressure and flow rates. Furnace temperature was monitored to 800°C with a type K thermocouple inserted through the orifice into the furnace cavity approximately 2 inches. At 800°C the thermocouple was removed and the orifice plate temperature was monitored with an optical pyrometer.

A heat-up schedule was maintained by observing furnace temperature and manually varying the power to the coil. A plot of the actual heat-up schedule is shown on p. 36, sec. 4.4. A log sheet from the dry run is included on p. 37-41, sec. 4.4.1.

3.4.1 Debugging and Operational Results

Operation of the induction remelt system during the dry run was remarkably smooth and trouble free. The major problems encountered were associated with the cooling water system. Supply pressure variations caused shutdowns of the motor generator set early in the run. Pressure switch was reset and no further problems were encountered. During the run, excessive condensation of the external surfaces of the cooling lines was evident. This problem was solved by insulating all cooling lines.

After the run was completed, the furnace was disassembled and inspected. Oxidation of the carbon components was minimal. No problem conditions were observed on any of the other furnace components.

3.5 Glass Remelting and Drawing Operation

3.5.1 Set Up

A. Glass Preparation - Finishing The glass for run 1 was obtained from a boule identified as 94-XXX, glass remaining from a ring seal segment. Glass for run 2 was from boule was installed on the furnace supply to automatically shutdown the furnace in the event cooling water flow was interrupted. A pressure gauge and thermometer were installed in the supply line for monitoring incoming water pressure and temperature. Rubber hose was used to connect from the main supply to the water cooled components. All lines were insulated to prevent condensation. Return lines were piped to a sight drain where flow could be monitored visually. Thermometers in the return water stream provided return water temperature data. Water was piped from the sight drains to an existing floor drain.

C. Purge Gas

Two gases were supplied to the furnace for purging. Nitrogen was delivered from an existing Linde 93VCC liquid nitrogen storage tank located outside the plant. The nitrogen was piped through a filter located ahead of the gas distribution and control panel. Argon was supplied from Linde GP-45 Liquid Storage Cylinders. Argon was also filtered prior to delivery to the gas distribution and control panel.

3.3.2 Equipment Installation

Installation of all equipment and services was by Canton plant's Trades and Electrical personnel. Existing installation tooling and equipment were adequate for completion of the project.

3.4 Equipment Start-Up

A "dry" run was conducted to evaluate the operation of the furnace system prior to remelting and drawing glass. The motor generator was brought up to speed and power was applied to the induction coil. System capacitance was varied in order to obtain the best possible loading. A fully assembled furnace, minus the glass charge, was heated to 1800°C over a 28 hour heat-up cycle. Nitrogen was used to purge the furnace throughout the run. The normal force (i.e. = 1). This force could vary between 0 and 50 pounds.

3.3 Installation

3.3.1 Facility and Process Services

A. Electrical Power

Power was required for operation of the motor generator set, pull-machine, and miscellaneous electrical equipment.

The motor-generator set requires power for a 150 HP, 480V, 3 phase AC motor. A Westinghouse fusible plug-in switch (model TAP-365) rated at 400 amps was installed in bus duct No. 4 (600A, 480V, 3Ø, 3W). The switch was fused with 3-225 amp dual element fuses in order to provide backup overload protection. Power was supplied to a fused disconnect switch positioned in a location visible and accessible from the motor generator set. The power was then supplied to the reduced voltage motor-starter controlling the motor.

Power for the pull machine and miscellaneous electrical equipment was supplied from existing circuits located in the furnace area.

B. Cooling Water

Water was required for cooling the motor generator set, capacitors, high frequency transformer, induction coil and furnace components. A connection was made to the existing plant process water system and piped to the furnace area. A cartridge type filter unit, capable of filtering 100 micron particles, was installed in line ahead of water cooled equipment. Separate supplies were provided from a 1 1/2" main supply line to individual furnace components. Manually controlled needle valves were used to regulate the flow to the equipment. A pressure switch furnace. Gas was introduced into the bottom of the furnace through a stainless steel manifold located between the inner and outer alumina cylinder, the outer alumina cylinder and susceptor, and between the susceptor and fused silica shell. Gas was delivered into the crucible through a carbon tube which extended from the center top plate through a hole in the top of the crucible.

E. Orifice

The orifice was designed for forming round cane. A round hole was drilled in a carbon plate tapered down from the outside diameter to the hole. The orifice is illustrated on p. 35, sec. 4.3.1.

3.2.3 Pull Machine Design

A detailed design for a downdraw type pull machine was provided by Corning's developmental melting department. Machines of the same design were used by this department in a development facility for pulling glass cane and strip.

A gear driven pair of rollers, rotating in opposite directions, is mounted approximately 6 - 7 ft. below the furnace so that glass can be fed between the rollers and pulled continuously. A variable speed motor with a range of 300 to 1800 RPM combined with a 300:1 speed reduction through gearing provided a 1 RPM to 6 RPM roller speed. With the 4" diameter rollers that were used, linear pull rate could be varied from 12.5 in./min. to 75 in./min.

Pulling force could be varied by regulating the pressure supplied to an air cylinder attached to a roller and lever arm assembly. An increase in pressure would increase the force applied at one end of a lever arm thus increasing the force applied normal to the glass by the roller which was mounted at the opposite end of the lever. The pull force was assumed to be approximately equal to the induction coil, fused silica outer shell, layered graphite felt blanket, and carbon susceptor. Centered in this furnace is a stacked arrangement which consists of a carbon crucible, carbon orifice plate, carbon support ring, carbon muffle plate and alumina cylinder.

Design of this stacked arrangement is such that by varying the height and/or diameter of various components the cooling rate of the drawn glass can be affected. All furnace components are contained between water cooled stainless steel plates on the top and bottom. Three stainless steel plates provide support for the furnace assembly. An outer plate supports the fused silica sleeve, layered graphite felt and carbon susceptor. A middle plate attaches the outer plate supports, the alumina ring, muffle plate, support ring, orifice plate and crucible assembly. An inner plate attached to the middle plate supports a high density alumina cylinder which is also used to control the cooling rate of drawn glass. Specifications of all components are included on pp. 27-34, sec. 4.3.

C. Glass Loading

A heavy duty single cup vacuum lifter was purchased for use in loading the glass into the furnace. Loading would be done through the top of the furnace prior to heating.

D. Purge Gas

A purge gas system was required to remove oxygen from the furnace cavity, preventing degradation of the carbon components due to oxidation at high temperatures. The system was designed for use with either nitrogen or argon as a purge gas. Purge gas was delivered from a pressurized liquid gas cylinder to a flow control panel consisting of a pressure regulator and a bank of flow meters for control of gas flow to various parts of the production of 2200 pounds of finished ULE™ glass strip 6.62" wide x (.050" - .100") thick x 25" long.

- Design an induction remelt furnace system using the I-100 motor generator set as the source of power. The furnace must be capable of remelting ULE™ glass for downdraw into strip form. The furnace will be designed to provide maximum possible charge and strip size.

- Develop a method for preparing and loading ULE™ glass feedstock for remelting.

- Specify and design a purge gas system for the induction furnace.

- Determine orifice design requirements and design orifice for downdraw of ULE™ glass. Determine methods of establishing glass flow.

- Assist plant personnel with installation and startup.

- Provide sufficient documentation and drawings to allow the Canton Plant to install and operate equipment.

Due to the developmental nature of this project an accurate evaluation of the capabilities of this system to produce strip of the size required was impossible. The evaluation indicated that this system did have the capability of producing strip in sufficient sizes and quantities to provide the process information that would be necessary for design of a production size furnace.

B. Furnace

The furnace was designed using the I-100 as the source of power. The furnace consists of a concentric arrangement of a water cooled furnace water pressure and system ground detection.

- Audible alarm for major fault indication.

Repair records showed that the Westinghouse Motor Generator received a major overhaul shortly before it was removed from service in 1980. The Inducto 100 was installed in the Canton Plant and tested to determine what repairs or modifications were necessary. The test included a general inspection of the unit by Engineers from Inductotherm Corp. and Corning. A summary of actions and recommendations is included on pp. 24-26, sec. 4.2

Operation of the Motor Generator Set was smooth and vibration free. No problems were experienced during this test. Furnace controls were operational. Control panel meter and the ground detector were defective. Cooling water hosing was deteriorated. The capacitance of the I-100 was not sufficient to match the inductance of the coil which was used for the test. The following actions were taken to refurbish the I-100 unit.

A. All control panel meters were replaced.

B. Capacitors replaced.

C. Water cooling hosing replaced.

D. Cooling water pressure switch replaced.

3.2.2 Furnace Design

A. Scope

Corning's Furnace Engineering Department provided detailed design for the induction remelt furnace. Prior to starting detailed design work, a scope of work to be done by furnace engineering was outlined as follows:

- Evaluate the capability of the system for came through the rollers.

B. Calculating the rate for each piece from one sample to the next:

$$\frac{\text{Length of Piece 2}}{\text{Elapsed time between piece 1 and piece 2}}$$

Pull rate at each pot setting is given on p. 68, sec. 4.7.6.

With a change in the pull rate effects on the product are evident. As the pull rate (inches per minute) increases the following linear effects are noted:

Weight per inch of product decreases (p. 69, sec. 4.7.7).

Diameter decreases (p. 70, sec. 4.7.8).

Attenuation increases (p. 71, sec. 4.7.9).

Mass throughput (in pounds per hour) can be determined by using the formula M = 60 PD where M= mass throughput in pounds per hour, P = pull rate in inches per minutes, D = Cane "density" in pounds per inch. In general mass throughput increased as the pull rate increased until the product became hollow. (p. 72, sec. 4.7.10).

Regressions were run on these relationships (pull rate vs. pot setting, lb/in, mass throughput, product diameter and attenuation) on the average values for each pot setting as listed in Table 8, Addendum VII. The equations, R-squared values, standard deviation and T-ratio are given on p. 73, sec. 4.7.11. In each case the relationships are significant.

As run 2 progressed the product quality degraded. A blue streak started in the center of the clear cane. This became several blue streaks. The product started to become foamy in the center. Occasionally bumps were evident. Finally the product became hollow. An X-ray tracing of the blue streak shows the product to be Ti-enriched. This is consistent with the EPR analysis performed in foamy glass remaining in the crucible at the end of Run 1.

As samples were being prepared for the CTE analysis (sandwich seals), it was found that the outer surface of the product devitrified during annealing. Surface analysis (with energy dispersive X-ray analysis or EDX) reveals the presence of Na, K, Ca, Cl and S. A one minute acid etch in hydrofluoric acid after cleaning the cane with xylene eliminated devitrification problems during annealing.

CTE results are discussed in detail in reports by H. Hagy. The average expansion of the feestock was -8 ppb/°C. The standard, composed of the same glass as the feedstock charge, average -6 ppb/°C. The observed was -4 ppb/°C, an excellent agreement with the expected result of -2 ppb/°C.

3.5.4 Conclusions

CTE

CTE results are discussed in two separate reports by H. Hagy. These reports conclude:

A. The average for run 2 was -4 ppb/°C.

B. CTE is a constant, preserved in remelting and drawing.

C. Blue streak material imparts a more positive expansion to the glass.

D. Expansion variability observed is the result of compositional variability (and not the result of the downdraw process itself.)

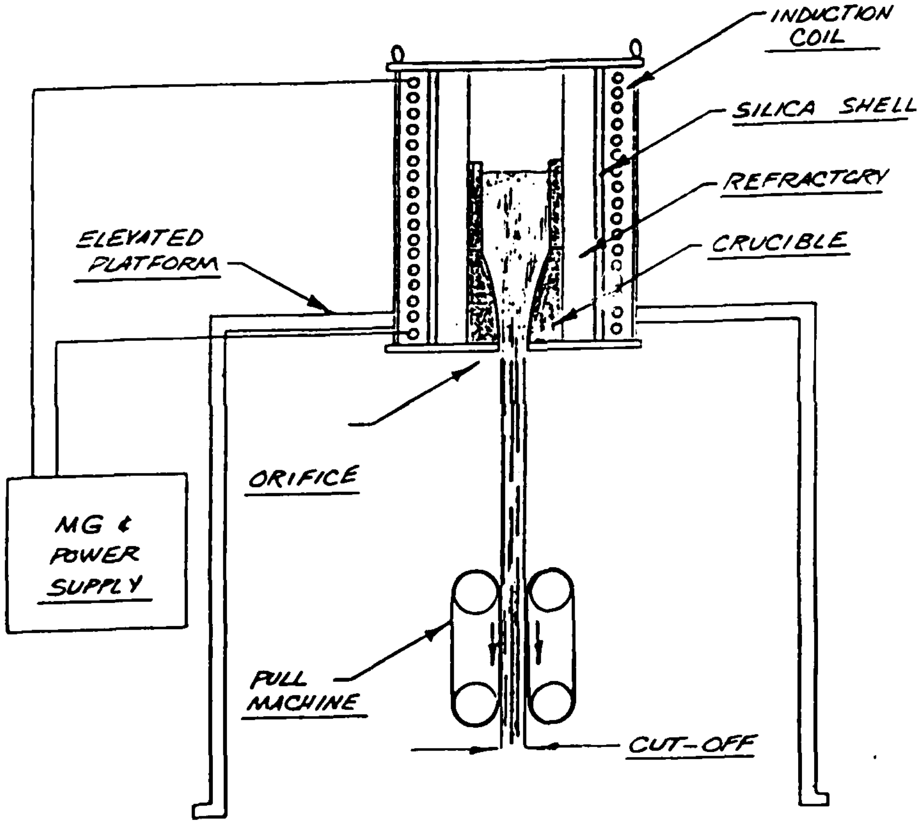
Reports by H. Hagy are attached on pp. 74-89, sec. 4.8.

Equipment

The equipment installed for Phase I performed satisfactorily and should be suitable for Phase II trails.

Given the observed attenuation ratio of 3 to 4 in Run 2, this furnace will probably not be large enough to draw strip wide enough to yield product with a 6.6" width.

DRAW


INDUCTION COIL
SILICA SHELL
REFRACTORY
CRUCIBLE
ELEVATED PLATFORM
ORIFICE
MG & POWER SUPPLY
PULL MACHINE
CUT-OFF

TO: **Mr. P. M. Smith**

cc: Mr. D. L. Prusha

FROM: W. E. Siebold/223-6802
Small Tanks & Heat Treat
Furnace Engineering
Melting Technology

DATE: February 24, 1984

SUBJECT: 100 KW Motor-Generator Set, Canton Plant

This memo is intended to review our conversations, work to date, and recommended future actions concerning the 100 KW, 3000 HZ motor-generator set. My first visit to Canton was on Wednesday, 2/1. The following actions were taken:

1. The removal of some external control and interlock wiring to restore the control circuit to an "as supplied" condition by Inductotherm.

2. M-G set appeared to be in good condition.

3. Much evidence of the 1972 flood mud remains inside the enclosure.

4. At least two meters are not working. Recommended that all six meters be replaced. New metering on order.

5. M-G set turned over and then brought up to speed. Bearings look and sound in good shape. No cooling water on.

6. T.C. field excitation tested. Approximately 100 volts open circuit generator volts obtained. Inductor coil was not connected. No cooling water on.

7. Inductor coil inspected. I felt that we could load into the coil (see below for negative results).

8. CGW safety people consulted by you concerning PCB insulated capacitors. May use them until 1988 as there are below 3+ pounds in each can.

9. Measured for Parker fittings to equate No. 12 and No. 16 fittings so water cooled inductor coil leads could be connected to the work coil.

My second visit was on Wednesday, 2/15, with the following work done:

1. Connected water circuits and tested system. Once circuit was not flowing, it was back flushed and then split into two circuits. The hoses were noted to be old and brittle. Their recommended replacement is underway.

2. Upon arrival of the Inductotherm serviceman, the M-G set was started and attempts made to load into the coil without success. Minimum generator voltage at excessive generator current was observed. M-G set was shut down and one 10.2 microfarad capacitor was added.

   M-G set restarted and loaded into coil at approximately 50 volts at 140 amps at the generator. PF meter not working.

   The coil appeared to have a minimum inductance causing relatively high current at low voltage to flow. Insufficient capacitors were on hand to swinge the load to unity power factor.

3. Ground detector circuit was tested and found not working. This subject should be examined carefully as an induction melting glass furnace may not need this circuit for protection. It also may be electrically difficult to connect in a meaningful manner.

The following recommendations have been mutually made and discussed with action programs listed:

1. Because the generator metering is the source of information for such future systems and three meters out of six are bad, a total new set is recommended. This set is now on order. Need for installation assistance is yet to be determined.

2. Because the interior of the water cooling hoses have grossly deteriorated, complete new hosing is recommended. The new hoses are now being installed.

3. The existing coil is a 3 parallel turn design with low inductance. It does not appear practical to use this coil.

   A new coil is recommended, 16 3/4" I.D. x 17 1/4" O.D. x 30" high with 25 to 30 turns and constructed with 1/2" O.D. copper tubing. The terminal fittings should be Parker Series 12 brass fittings to mate with the terminals on the water cooled leads.

   This coil could be ordered from Inductotherm or made at the Canton plant. No work on the coil, however, should occur until it can be coordinated with the furnace design.

4. Because of a 10-12 week lead time, it is recommended that the equivalent of 5-10.2 microfarad, 1250 volts, 300 KVAR capacitors be placed on order.

   With a new coil design, the following tabulation indicates that the above capacitors may not be needed. Until the coil design is firmed up, we may want the protection.

Coil Turns	Max Volts At 50 KW (Work)	No. Of Cans For 200 KVAR
15	300	11.6 (12)
20	400	6.5 (7)
25	500	4.2 (5)
30	600	2.9 (3)

   To use the existing coil consisting of 3 parallel 7 turn sections, I calculate that 22 capacitor cans each rated 10.2 microfarad would be required to load at unity power factor. It does not appear viable to use this coil.

5. The need for new water cooled leads will depend upon your completed layout. If required, they will be ordered from Inductotherm.

I believe that the above reflects the action taken to date and the mutually discussed recommendations. Please let me know when I may be of further assistance.

JMF6/E

FUSED SILICA MELTER
K-84-A
CANTON, N.Y.

SPECIFICATIONS	DRAWING NUMBER
Assembly	12822-4801

DESCRIPTION	DRAWING NUMBER
Fused Silica Melter	12822-4801
Middle Bottom Plate	12822-4811
Top Bottom Plate	12822-4821
Suscepter Top	12822-1292
Lower Bottom Plate	12822-1302
Top Plate	12822-1312
Gas Distribution Tube	12822-1322
Orifice Plate	12822-1373
Muffle Plate	12822-1383
Suscepter Cover	12822-1393
Gasket	12822-1403
Susceptor Bottom	12822-1413
Plug	EMP-F-000-71
Top Plate	EMP-QR-50
Top Plate & Plug Assy. (Ref.)	EMP-F-000-81
Bushing	24132-484A
Bushing, Isolation	24972-64A

2/84
RCB/b

Rev.		Rev.		Rev.		Sheet 1 of 7	Date 2/84	Repair Date	Fused Silica Melter Assy SPECIFICATIONS
						Bul. No.	By RCB		MELTING TECHNOLOGY
						Dwg. No. 12822-4801		Unit & Plant K84A	Canton

Rev.	Item No.	USE and DESCRIPTION	DWG. NO.	MATERIAL	REQ'D	ALLOT	ORDER	EST.	UNIT COST	TOTAL COST
	1	Plug - Top Plate & Hold Down Clip	EMP-F-000-71		One Assy (Existing)					
	2	Top Plate Modified	12822-1312		One Assy					
		(1) Top Plate	EMP-QR-50		One Assy (Existing)					
		(2) Bar 3/16" x 1" x 8"		309 Stn Stl	8					
		(3) Bar 3/16" x 2" x 8"		309 Stn Stl	4					
	3	R. F. Coil & Support		Com'l	One					
	4	Fused Silica Tubing		T43	One (Existing)					
		15" I.D. ± ¼", ½" Wall ± 1/8" x 40" LG		Opaque						
		Rotosil T43 Opaque								
		Heraeus-Amersil, Inc.								
		650 Jernees Mill Road								
		Sayreville, NJ 08872								
		(201) 254-2500								
	5	Gasket	12822-1403	Silicone	2		4			
		¼" Thk x 14 ½" I.D. x 16 1/2" O.D.		Rubber						
		Sealing Devices								
		6660 Joy Road								
		East Syracuse, NY 13057								
		(315) 437-8397								

Rev		Rev.		Rev.		Sheet 2 of 7	Date 2/84	Repair Date	Fused Silica Melter Assy SPECIFICATION
						Bul. No.	By RCB		MELTING TECHNOLOGY
						Dwg. No. 12822-4801		Unit & Plant K84A	Canton

Rev.	Item No.	USE and DESCRIPTION	DWG. NO.	MATERIAL	REQ'D	ALLOT	ORDER	EST.	UNIT COST	TOTAL COST
	6	Top Bottom Plate	12822-4821		One Assy					
		(1) Plate ½" x 17" Dia.		309 Stn Stl	One					
		(2) Plate ½" x 29 ½" Dia.		309 Stn Stl	One					
		(3) Block Bar ½" x 5/8" x 1"		309 Stn Stl	One					
		(4) Pipe ½" SCH 40 x 7/8" LG		309 Stn Stl	One					
	7	Middle Bottom Plate	12822-4811		One Assy					
		(1) Plate 3/16" x 12 3/8" Dia.		309 Stn Stl	One					
		(2) Plate ½" x 10 ½" Dia.		309 Stn Stl	One					
		(3) Block Bar ½" x ½" x 5/8"		309 Stn Stl	One					
	8	Lower Bottom Plate	12822-1302		One Assy					
		(1) Plate 3/16" x 8 5/8" Dia.		309 Stn Stl	One					
		(2) Plate 3/8" x 7 ½" Dia.		309 Stn Stl	One					
		(3) Pipe ½" SCH 40 x 9/16" LG		Copper	One					
		(4) Pipe ½" SCH 40 x 1 ½" LG T.O.E.		Copper	2					
	9	Gas Distribution Tube	12822-1322-1		One Assy					
		Tubing ½" O.D. x 20 Ga. Wall x 21 1/8"		316L Stn Stl	One					
	10	Gas Distribution Tube	12822-1322-2		One Assy					
		Tubing ½" O.D. x 20 Ga. Wall x 35"		316L Stn Stl	One					

Rev.		Rev.		Rev.		Sheet 3 of 7	Date 2/84	Repair Date	Fused Silica Melter Assy SPECIFICATIONS
						Bul. No.	By RCB		MELTING TECHNOLOGY
						Dwg. No. 12822-4801		Unit & Plant K84A	Canton

Rev	Item No.	USE and DESCRIPTION	DWG. NO.	MATERIAL	REQ'D	ALLOT	ORDER	EST.	UNIT COST	TOTAL COST
	11	Gas Distribution Tube	12822-1322-3		One Assy					
		Tubing ¼" O.D. x 20 Ga. Wall x 45 1/8"		316L Stn Stl	One					
	12	Inner Muffle Sleeve		99.8% Al_2O_3	One		3			
		5" I.D. x ¼" Wall x 8" LG								
		McDanel Refractory Co.								
		510 Ninth Ave., Box 560								
		Beaver Falls, PA 15010								
		(412) 843-8300								
	13	Outer Muffle Sleeve		Norton	One		3			
		8" I.D. x 1" Wall x 7 3/4" LG.		AN498						
		Norton Industrial Ceramics Div.								
		Worcester, MA 01606								
	14	Muffle Plate	12822-1383	873 RL	One		2			
		1" Thk x 11" Dia.		Carbon						
		Purchase from:								
		Airco Carbon								
		800 Theresia Street								
		St. Marys, PA 15857								
		(814) 781-2644								

Rev.	Rev.	Rev.	Sheet 4 of 7	Date 2/84	Repair Date	Fused Silica Melter Assy SPECIFICATION
			Bul. No.	By RCB		MELTING TECHNOLOG
			Dwg. No. 12822-4801		Unit & Plant K84A	Canton

Rev	Item No.	USE and DESCRIPTION	DWG. NO.	MATERIAL	REQ'D	ALLOT	ORDER	EST.	UNIT COST	TOTAL COST
	15	Support Ring		873 RL	One		3			
		10.00" ± .02" I.D. x .50" Wall .00		Carbon						
		x 2 ½" ± .02" Long								
		Purchase from:								
		Airco Carbon								
		See Item no. 14								
	16	Orifice Plate	12822-1373	873 RL	One		5			
		1.50" ± .02" Thk x 11.00" ± .02" Dia.		Carbon						
		Purchase From:								
		Airco Carbon								
		See Item No. 14								
	17	Crucible		873 RL	One		3			
		10.00" ± .02" I.D. x .50" Wall .00		Carbon						
		x 23.50" ± .02" Long								
		Purchase From:								
		Airco Carbon								
		See Item No. 14								

Rev	Rev.	Sheet 5 of 7	Date 2/84	Repair Date	Fused Silica Melter Assy SPECIFICATION
		Bul. No.	By RCB		MELTING TECHNOLOG
		Dwg. No. 12822-4801		Unit & Plant K84A	Canton

Rev	Item No	USE and DESCRIPTION	DWG. NO.	MATERIAL	REQ'D	ALLOT	ORDER	EST.	UNIT COST	TOTAL COST
	18	Susceptor Top	12822-1292	873 S	One		3			
		12.625" ± .020" O.D. x 11.75" ± .02" I.D.		Carbon						
		x 28" ± .01" LG								
		Purchase From:								
		Airco Carbon								
		See Item No. 14								
	19	Crucible Cover	12822-1393	873 RL	One		3			
		1.00" ± .02" Thk x 11.50" ± .02" Dia.		Carbon						
		Purchase From:								
		Airco Carbon								
		See Item No. 14								
	20	Spacer		873 S	One		3			
		3/4" I.D. x ½" Wall x 6" (Cut To Fit)		Carbon						
		Purchase From:								
		Airco Carbon								
		See Item No. 14								
	21	Rod, Brass 3/8" Dia. x 44" LG		Com'l	4					
		T.B.E. 3/8" - 16 UNC x 2" Furnish								
		With Brass Nut & Flat Washer								

Rev.		Rev.		Rev.		Sheet 6 of 7	Date 2/84	Repair Date	Fused Silica Melter Assy SPECIFICATIONS
						Bul. No.	By RCB		MELTING TECHNOLOGY
						Dwg. No. 12822-4801		Unit & Plant K84A	Canton

Rev.	Item No.	USE and DESCRIPTION	DWG. NO.	MATERIAL	REQ'D	ALLOT	ORDER	EST	UNIT COST	TOTAL COST
	22	Conduit 3/4" Aluminum Thin Wall		Com'l	4					
		x 41 ½" LG ± 1/32"								
	23	Bushing 3/4" Thk x 1 ½" Dia.	24132-484A	Steatite	4					
	24	Isolation Bushing 3/8" Thk x 1 ½" Dia.	24972-64A	Steatite	4					
	25	Screw, Soc. Hd Cap 309 Stn Stl		Com'l	8					
		10-32 UNF x ½" LG								
	26	Graphite Felt Blanket		Com'l	7 Yards		21 Yards			
		½" Thk x 36" - 40" Wide Cat. No. X-3101								
		Union Carbide Co. Carbon Products Div.								
		120 S. Riverside Plaza								
		Chicago, IL 60606								
	27	O-ring Parker #2-446-V747-75		Fluoro-	One		4			
		8.475" I.D. W = .275"		carbon						
		Parker Seal Group								
		6660 Joy Road								
		E. Syracuse, NY 13057								
		(315) 437-8397								

Run 1 Heat-Up Schedule	Cum. Hours
Heat 100°C/hr to 600°C	6
Hold 600°C for 4 hours	10
Heat 100°C/hr to 1650°C	20.5

Actual start-up: Tuesday, 6/5/84 at 10 am.

Run 2 Heat-Up Schedule	Cum. Hours
Heat 100°C/hr to 600°C	6
Hold 600°C for 3 hours	9
Heat 150°C/hr to 1650°C	16

Actual Start-Up Time: Tuesday, 6/19/84, at 9 pm.

ULE DOWNDRAW FURNACE

START UP PROCEDURE

SET UP

1. 8 hours before scheduled start up open the inert gas line. Set nitrogen pressure to 10. Set each flow meter to 5 l/min.

2. Check water filters. Replace if not clean.

START UP

1. Open cooling water through filter.

2. Check for adequate water outlet flow through motor generator, coil, cabinet, and plates.

3. Turn main power switch to on.

4. Set generator voltage % to zero.

5. Set furnace voltage control to tap 7.

6. Switch in numbers 1, 2, 3, 4, 5, 6 on capacitor control.

7. Reset cabinet with, generator air temperature, generator overload and furnace water buttons.

8. Pull starter handle down. Hold in start position for 60 seconds. Push starter handle through stop and into run position.

9. Push on generator field.

10. Reset starter interlock.

11. Push on main line contactor.

12. Turn up generator voltage control to initial setting.

ABSOLUTE EXPANSION READINGS - DOWNDRAW FEEDSTOCK, RUN 2

		RADIAL					AXIAL		
PIECE #		AXISA	AXISB	AXISC	AVERAGE	GRAND AVE	DEPTH	ABS EXP	AVG
4	0	-9	-	-	-9		1/4	-3	-6
	1	-8	-10	-8	-9		1/2	-5	
	2	-7	-9	-8	-8	-8	3/4	-6	
	3	-6	-9	-7	-7		1	-5	
	4	-4	-8	-8	-7		1 1/4	-3	
							1 1/2	-3	
5	0	-9	-	-	-9		1 3/4	-2	
	1	-8	-8	-9	-8		2	-1	
	2	-7	-8	-8	-8	-8	2 1/4	0	
	3	-7	-8	-8	-8		2 1/2	-3	
	4	-6	-7	-8	-7		2 3/4	STRIEA	
							3	-13	
6	0	-9	-	-	-9		3 1/4	-12	
	1	-9	-9	-9	-9		3 1/2	-11	
	2	-9	-9	-9	-9	-9	3 3/4	-10	
	3	-8	-9	-8	-8		4	-10	
	4	-7	-9	-9	-8		4 1/4	-9	

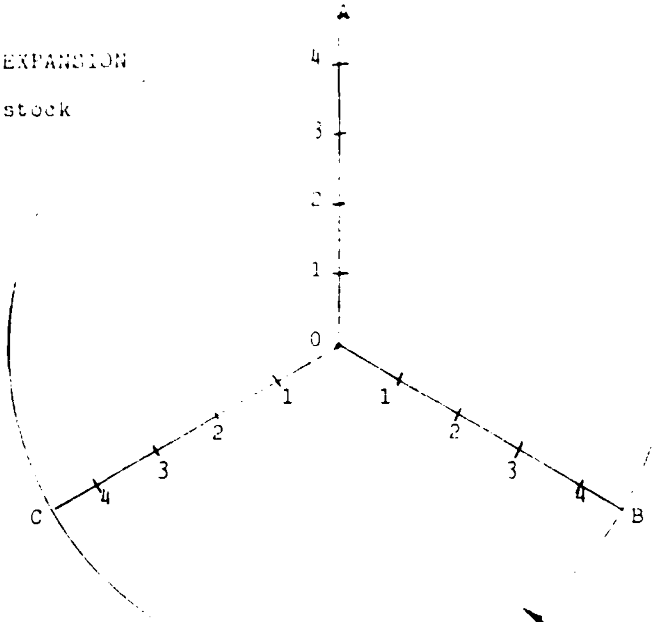
ABSOLUTE EXPANSION READINGS - DOWNDRAW FEEDSTOCK, RUN 1

		RADIAL					AXIAL		
PIECE #		AXISA	AXISB	AXISC	AVERAGE	GRAND AVERAGE	DEPTH	ABS EXP	AVG
1	0	-5	-	-	-5		1/4	-3	-6
	1	-5	-4	-5	-5		1/2	-5	
	2	-4	-4	-6	-5	-4	3/4	-6	
	3	-4	-3	-7	-5		1	-10	
	4	-4	0	-7	-4		1 1/4	-15	
							1 1/2	-8	
2	0	+7	-	-	+7		1 3/4	-5	
	1	+6	+6	+6	+6		2	-3	
	2	+5	+4	+4	+4	+4	2 1/4	-2	
	3	+3	+2	+3	+3		2 1/2	-3	
	4	+2	+2	-1	+1		2 3/4	-5	
							3	-6	
3	0	-8	-	-	-8		3 1/4	-4	
	1	-7	-7	-7	-7		3 1/2	-4	
	2	-6	-7	-7	-7	-6	3 3/4	-8	
	3	-7	-5	-7	-6		4	-7	
	4	-6	-3	-6	-5		4 1/4	-2	

[illegible]UTE READING SITES

RADIAL ABSOLUTE EXPANSION
Reading Sites
Top View of Feedstock

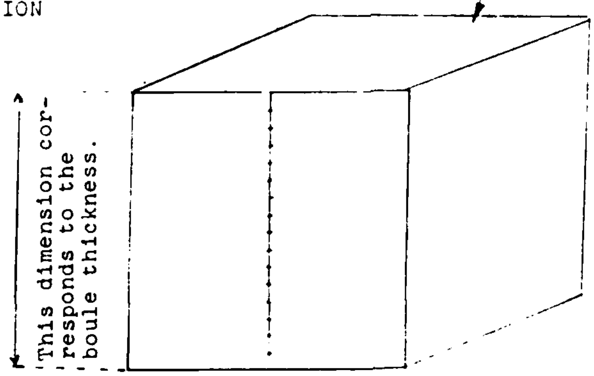
Reading Taken on
Three Axes, 120°
Apart, at 1"
Intervals.



This surface is
the top of the
boule.

AXIAL ABSOLUTE EXPANSION
Reading-Sites-
Side View of STD

Readings Taken Every
1/4" of Depth



SCALE
= 1"

NOTE: Axial readings of standard and feedstock should be equal since they are from the same boule.

FEEDSTOCK DIMENSIONS AND WEIGHT

Run	BOULE	PIECE NO.	DIAMETER	THICKNESS	WEIGHT	POSITION IN FURNACE
1	94-XXX	1	9.49"	4.426"	25.0 lb	BOT
		2	9.50"	4.426"	25.0	MID
		3	9.49"	4.433"	25.0	TOP
		TOTAL		13.285" [a]	75.0 lb [b]	
2	34-109	4	9.49"	4.422"	25.0	BOT
		5	9.49"	4.421"	25.0	MID
		6	9.48"	4.422"	25.0	TOP
		TOTAL		13.265" [a]	75.0 lb [b]	

a charge height

b charge weight

ULE REMELTER LOGSHEET

DATE 5-23- GLASS CODE ULE- Dry Run

Shift	Operator
11:00-07:00	
07:00-04:00	
04:00-11:00	

TIME	GENERATOR OPERATION						CAPACITOR CONTROL (In-Out)					WATER FLOW							TEMPERATURE, C.	
	Volts, A.C.	Amps, A.C.	K.W.	Pow. Fac.	Amps, D.C.	Volts, A.C.	1	2	3	4	5,6,7,8,	Generator On	Generator In	Generator Out	Furance 1	Furance 2	Furance 3	Furance 4	Furnace	Muffle
							GVC												plate	on tile
[illegible]	280	55	13	1	2	350	85	20												1540
[illegible]													57	78/90	67	70	70	62	1375	1590
1546	280	52	12	1	2	350	25	00						73/84	62	61	62	62	1284	1479
1600	280	52	12	1	2	350	25	00					57	78/77	62	71	72	62	1225	1365
1607							20													
1620			6				20													1270
1630	170	38	7	.995			20					water pressure 46								1210
1630		turned	gen	volt		down	10					gas flows @ 5, gas pressure @ 12								
1635			"	"	"	"	0	MF turned off Killed power				(all water on (tank, ball, cabt)								
1645																				1120
1700																				1005
1745																				800

ULE REMELTER LOGSHEET

DATE 5/23/84 GLASS CODE [illegible]

Shift	Operator
11:00-07:00	
07:00-03:00	M.F.S.
03:00-11:00	

TIME	GENERATOR OPERATION Volts, A.C.	Amps, A.C.	K.W.	Pow. Fac.	Volts, D.C.	Volts, A.C.	CAPACITOR CONTROL (In-Out) 1	2	3	4	5,6,7,8	WATER FLOW Generator On	In	Out		Furance 1	2	3	4	TEMPERATURE, C. Furnace		Muffle
Start 5/23/84							ON Volt	GAS FLOWS 1	2	3	4			cal	col					Temp Calc	Orifice	1415 - H_2O in lid for 40
0915	375	76	24	.995	2.9	510	35	8	8	10	5		53	82	82	76	76	82	64	1385	1515	flame from orifice
0930	375	77	24	.988	2.9	500	35	8	8	10	5		58	82	88	76	80	80	63	1325	1540	
45	375	77	24	.968	2.9	525	35 37	8	8	10	5		59	82	88	78	82	80	62	1415	1570	
0955																						
1000	420	82	28	.985	3.1	545		8	8	10	5		59	82	88	80	68	80	62			Muffle Temp
15	440	82	28	.985	3.1	545	37	8	8	12	5		59	82	86	80	68	80	62	1460	1600	
1030	400	82	27	.985	3.1	545	37	8	8	10	5		59	82	88	80	68	81	63	[illegible]	1625	1430 — 1320
45	420	82	27	.985	3.1	545	37	8	8	10	5		56	82	87	80	68	76	62	1490	1640	1550 — T-1540
1100	410	82	27	.984	3.1	540	37	8	8	10	5		59	82	86	81	68	76	62	1500	1650	1490 — M-1455
1115														~~82~~	~~88~~	~~87~~	~~68~~	~~76~~	~~62~~	1515	1650	1335 — B-1380
													~~59~~				~~68~~			~~[illegible]~~	~~[illegible]~~	
1120	410	85	30	.982	3.2	560	39															
1130	410	85	30	.982	3.2	560		8	8	10	5		59	82	82	82	68	76	62	1320	1620	
1145	410	75	32	.982	3.3	560	38.5	8	8	10	5		55	82	84	82	69	78	62	1540	1700	1130 - More flow on
1147							35													~~1520~~	~~1645~~	cool H_2O circuit
1200																				1530	1675	-160°F Bottom plate
1202	400	85	28	.98	3.2	590	37	8	8	10	5		57	82	89	82	68	76	64	[illegible]	1665	Contact T/C.
1215	425	86	31	.98	3.3	574	39	8	8	10	5		59	82	89	82	68	76	63			
1230	420	86	31	.98	3.3	525	39	8	8	10	5		59	82	89	82	68	76	63	[illegible]	1705	
1245	415	86	31	[illegible]	[illegible]	515	41	8	8	10	5		59	87	90	78	77	70	69	[illegible]	1725	(smoke)
1249	4						41.25	8.5	8.5	9	3		59	82	91	66	70	78	62	1585	1755	Saw flame 1 1/2"
1300	430	90	33	.98	3.4	598	40.25	8.5	8.5	9	3		57	82	91	[illegible]	[illegible]	[illegible]	62			Bottom of
1315	430	90	33	.98	3.4	590								82	91	64	80	78	62	1397	1765	orifice
1330	430	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40	9.5	[illegible]	9	3		57	82	91	64	80	80	62	[illegible]	[illegible]	
45	440	91	34	.98	3.5	600	40	[illegible]	[illegible]		3		56	82	91	63	81	[illegible]	62	[illegible]	[illegible]	
1400	440	90	34	.98	3.5	600	40.75	9.5	8.5	9	2		59	82	92	63	82	80	64	1640	1805	
1400							40.													~~1640~~		Went to H_2O by [illegible]
1415	425	90	33	.98	3.5	590	40	9.5	8.5	9	2	•		78	82	62	74	74	64	1640	1805	Chg. J. T[illegible]
1430	432	[illegible]	[illegible]	[illegible]	3.4	615	[illegible]	[illegible]	[illegible]	9	2		57	72	82	70	73	71	72	1647	1805	
1445	430	90	33	.98	3.4	615	41 40	8.5	8.5	9	2		59	82	82	71	73	73	72	1640	1802	
1455																				1630	1790	
1500																				1640	1790	
[illegible]																					[illegible]	
	Burn [illegible]																					

ULE REMELTER LOGSHEET

DATE 1/23 GLASS CODE [illegible]

Shift	Operator
11:00-07:00	[illegible] - [illegible] - MFS
07:00-04:00	
04:00-11:00	

TIME	GENERATOR OPERATION						CAPACITOR CONTROL (In-Out)					WATER FLOW							TEMPERATURE, C.	
	Volts, A.C.	Amps, A.C.	K.W.	Pow. Fac.	Volts, D.C.	Volts, A.C.	GVC 1	2	3	4	5,6,7,8	Generator °C			Furnace °F				Furnace	Muffle
												On	In	Out	1	2	3	4	Inside Plate	
0200	300	50	12	1	2.0	350	GEN [illegible] 25	8	8	10	[illegible]		52	80/79	65	71	76	64	1276 975	
0215														80/78	66	70	75	64	1050 973	OPENED BYPASS
[illegible]	260	50	12	1	2.	350								81/79	64	70	76	64	1053 980	TO MAINTAIN
[illegible]	260	50	12	1	2.	350							58	81/79	66	72	75	64	1052 980	20 PSI WATER PRESSURE
[illegible]													59	81/79				64	1058 980	
0315													58	81/79	67	70	77	63	[illegible] 989	
[illegible]													58	81/71	67		77	64	[illegible] 980	
[illegible]													50	[illegible]	67		77	65	[illegible]	
[illegible]													58	72/79	68	72	74	62	1055 985	
0415	260	50	12	.99+	1.9+	350	25	8	8	10	5		58		66	70	74	64	1060 980	MFS Reading
0430	260	50	12	.99+	1.9+	350	25	8	8	10	5		58	80/78	66	70	74	64	1060 980	
0430							27												~~1025 1000~~	
0445	290	56	14	.99+	2.1	390	27	8	8	10	5		58	80/78	68	72	78	64	1070 1000	
0500	290	56	14	.99+	2.1	390	27	8	8	10	5			80/78	68	72	78	64	1090 1015	
0500							28												~~[illegible]~~	~~Readings from~~
0515	300	58	15	.99+	2.11	400	28	8	8	10	5		58	80/80	68	72	78	64	1100 1045	Readings from Floor
0520														80/80					1075	Inside Bottom Plate
0530	300	58	15	.99+	2.11	400	28	8	8	10	5			80/80	68	74	80	64	1145 1065	
0545	300	58	15	+.99+	2.11	400	28	8	8	10	5		58	80/80	68	74	80	64	1165 1060	
0600	300	58	15	+.99+	2.11	400	28	8	8	10	5			80/80	68	76	80	64	1185 1040	
0615	300	58	15	+.99+	2.11	400	28	8	8	10	5		58	80/80	70	78	85	64	1190 1100	[illegible]
0615							30													Increased [illegible]
0630																			1220 1125	
0645	320	64	19	+.99	2.4	420	30	8	8	10	5		58	80/82	70	78	70	70	1235 1135	
0645	350	70	20	.99	2.7	470	33	8	8	10	5		58							Increased GVC
0700																				
0715	350	70	21	.99	2.7	470	33	8	8	10	5		58	80/86	70	80	92	64	1350 1225	
0730	350	70	21	.99	2.7	470	33	8	8	10	5	•		80/86	70	78	74	64	1365 1260	
0745	[illegible]																			
0800	350	70	21	.99	2.7	470	33							82/85	72	78	76	64	1410 1300	[illegible]
0815	350	70	21	.99	2.7	470	33	8	8	10	5		58	82/85	72	80	76	64	1430 1310	
[illegible]		21	21	[illegible]		[illegible]							53	[illegible]			14	[illegible]	1450 [illegible]	
[illegible]				[illegible]										[illegible]				[illegible]	[illegible]	
0845	[illegible]						35													

H2O Inlet Press 20#30 w/Bypass

Dead

Raising Top above support

DATE 5-22 GLASS CODE Dry Run - NO GLASS

ULE REMELTER LOGSHEET

Shift	Operator
11:00-07:00	
07:00-04:00	
04:00-11:00	[illegible]

TIME	GENERATOR OPERATION Volts, A.C.	Amps, A.C.	K.W.	Pow. Fac.	Volts, D.C.	Volts, A.C.	CAPACITOR CONTROL 1	2	3	4	5,6,7,8,		WATER FLOW Generator On	In	Out	Furance 1	2	3	4	TEMPERATURE, C. Furnace		Muffle	
							Gen Voltage Control		Gae Tous C/hr														Type K T/C
18:30	180	35	6	.11+	1.3	249	19	.0	1	2	3	4		60	78	61	61	71	64			[illegible]	
[illegible]	180	[illegible]	[illegible]	[illegible]	1.3	249	[illegible]	[illegible]						[illegible]	78	61	61	[illegible]	63			[illegible]	
19:00	180	35	[illegible]	[illegible]	1.3	252	19	.6						59	73	62	62	72	64			638	
19:15	180	35	6	1.0	1.3	250	17	.0						59	79	62	62	[illegible]	64			636	
19:30	180	35	6	1.0	1.3	250	17	.0	5	5	5	5		57	77	61	61	72	63			643	
[illegible]	180	35	6	1.0	1.3	250	19	.6	8	8	10	5		57	77	61	61	71	63			631	
20:00	180	35	6	1.0	1.3	250	19	.0	8	8	10	2		57	79	61	61	72	64			635	
[illegible]15	182	35	6	1.0	1.3	250	19	.2	8	8	10	2		57	77	61	61	72	64			632	(1) 5 pH +
[illegible]	increased to 2nd range						22	0															H₂O cooling
[illegible]	220	42	9	.98	1.6	300	22	.0	8	8	10	2		59	79	61	61	72	64			674	for low circuit
20:45	220	42	9	.99+	1.6	300	22		8	8	10	5		59	80/80	61	61	72	64			704	
2100	220	42	9	.99+	1.6	300	22								80/81	64	64	76	64			723	(2) Inside H₂O Lines
2100							23															~~748~~	
2115	220	42	9	.99+	1.65	300								59	80/66	64	64	78	64			748	(3) Dp Gems
2115							24																1 lb/hr 20 psi
2125							25																10/30
2130	250	50	12	.99+	1.9+	350									80/70	64	64	68	64			783	
2145	250	50	12	.99+	1.9+	350	25		[illegible]	[illegible]	1	[illegible]			80/70	64	64	68	64	[illegible]	[illegible]	830	[illegible]
2200	251	50	12	[illegible]	2.0	351	25		8	8	10	5		59	80/70	61	[illegible]	72	62	[illegible]	830	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	[illegible]	[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47	8-12	[illegible]	
[illegible]	[illegible]	[illegible]	13	[illegible]	2.0	350			8	8	10	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	71	62	[illegible]	870	[illegible]	at [illegible]
[illegible]	300	[illegible]	13	1	2.0	350			+	+	+	+		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65	[illegible]	875		
[illegible]	300	[illegible]	13	1	[illegible]	350								58	[illegible]	[illegible]	68	72	65	[illegible]	90C		
[illegible]15	260		[illegible]	1		[illegible]								58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	772	912		
[illegible]30	260	[illegible]				[illegible]								[illegible]	[illegible] 76	68	68	[illegible]	[illegible]	[illegible]	926		
[illegible]45	[illegible]				[illegible]	[illegible]								58	80/76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	932		
[illegible]	[illegible]				[illegible]	[illegible]								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	945		
[illegible]	[illegible]													[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	952		
[illegible]														[illegible]	80/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]														[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
2400														[illegible]	[illegible]	61	[illegible]	76	[illegible]	[illegible]	[illegible]		
2415														[illegible]	[illegible]					[illegible]	962		
[illegible]															[illegible]					[illegible]	963		
[illegible]														[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	962		

DATE 5/22/ GLASS CODE -DRY 200-NO GLASS

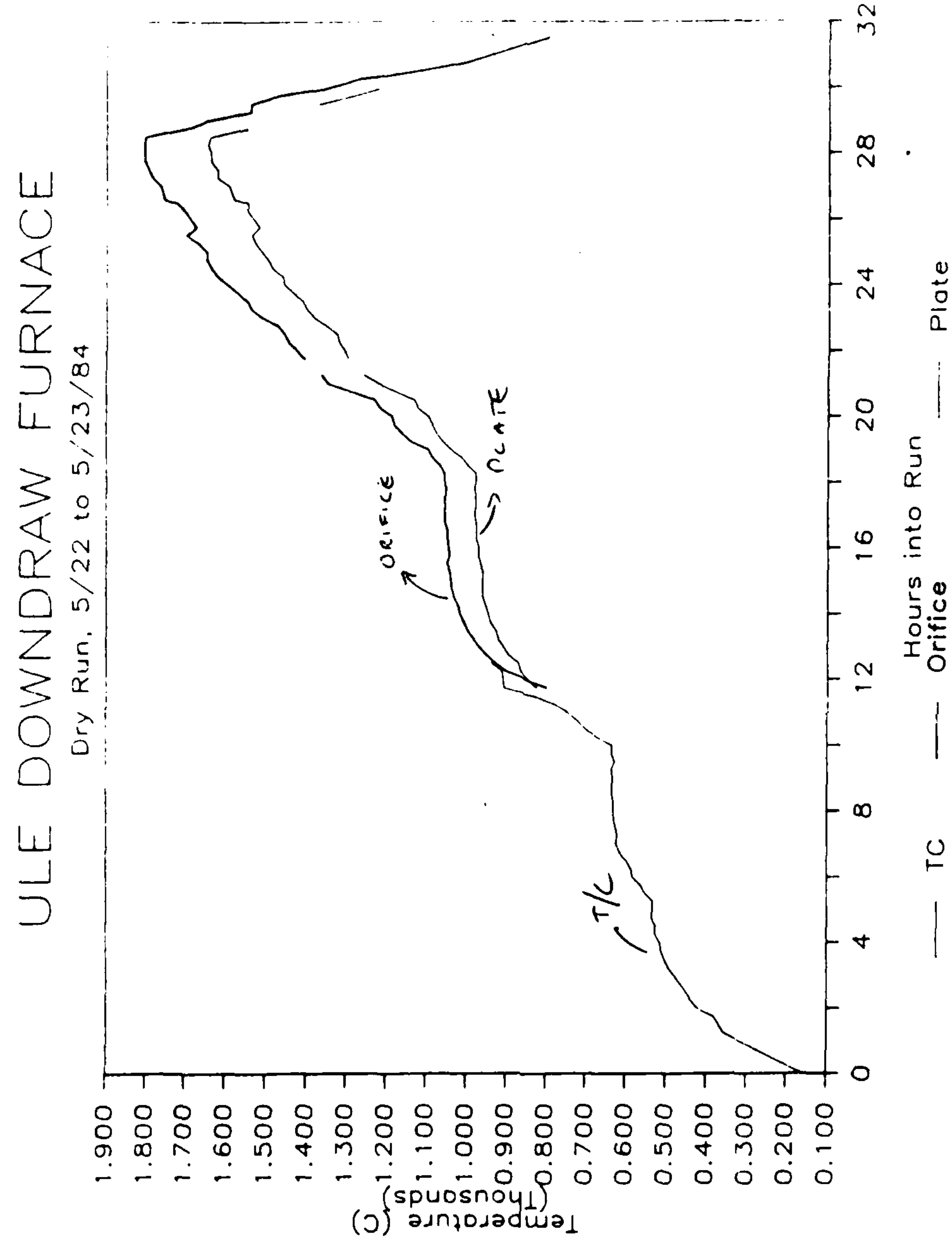
ULE REMELTER LOGSHEET GAS FLOW

Shift	Operator
11:00-07:00	
07:00-04:00	BL-5-22-84
08:00-11:00	[illegible]

TIME	GENERATOR OPERATION						CAPACITOR CONTROL (In-Out)					WATER FLOW							TEMPERATURE, C.	
	Volts, A.C.	Amps, A.C.	K.W.	Pow. Fac.	Volts, D.C.	Volts, A.C.	1	2	3	4	5,6,7,8	Generator °F			Furance °F				Furnace	Muffle
												On	In	Out	1	2	3	4		
1020	150	30	5	1	1	200	✓	✓	✓	✓	✓								Col Inpt	158 Tipek T/C
	400	72	25	.98	2.8	525	— TAP No 7					—							305	167
	550	100	50	.97	4.1	775													433	181
1025	Lost	H2O	Pressure																	257
1038	"	"	"	[illegible]									60	78	60	58	62	64		274
1115																				335
1130	160	30	5	1	1.2	225	Generator Control Voltage (17.25)						60	78	60	58	62	64		360
1145	160	32	5	1	1.2	225							60	78	60	58	62	63		
1200	160	32	5	1	1.2	225							60	78	60	58	62	63		383
15	160	32	5	1	1.2	225							60	78	60	58	63	63		424
30	160	32	5	1	1.2	220							60	78	60	58	63	62		441
45	160	32	5	1	1.2	220							60	79	60	58	63	62		453
1300	165	32	5	1	1.2	225	17.50						60	80	60	58	63	62		467
15	[illegible]	32	5	1	1.2	225	17.50						60	80	[illegible]	[illegible]	[illegible]	[illegible]		482
1330	160	32	5	1	1.2	225	17.50						60	80	60	58	66	62		497
45	160	32	5	1	1.2	225	17.50						60	80	60	58	68	62		509
[illegible]	[illegible]	32	5	1	1.2	225	17.50						60	80	60	60	68	62		516
15	[illegible]	32	5	1	1.2	225	17.50						60	80	61	60	69	62		518
30	160	32	5	1	1.2	225	17.50						60	80	61	61	68	62		530
45	160	31	5	1	1.2	230	17.50						60	81	61	61	72	62		531
1500	160	[illegible]	5	1	1.2	230	17.75						62	80	62	62	71	66		542
1526	[illegible]	[illegible]	[illegible]	1	1.2	230	17.50						62	80	61	[illegible]	72	61		536
1530	165	37	5.5	1	1.25	240	17.80						62	80	62	[illegible]	[illegible]	[illegible]		536
1545	170	[illegible]	[illegible]	1	1.4	[illegible]	19.20						62	80	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
16.00	170	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	19.	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]							[illegible]	[illegible]			[illegible]		
16.32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]
[illegible]	[illegible]						[illegible]							[illegible]						[illegible]
17.00	190	36	6	.99+	1.4	260	20.0						62	80	61	61	70	63		619
17.15	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]						[illegible]	79	[illegible]					629
17.1?	Reduced	[illegible]		[illegible]		14.0														
17.30	19.	[illegible]	[illegible]				19.0						[illegible]	79	[illegible]			[illegible]		624
17.45	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]							[illegible]	[illegible]						
18.00	180	35	6	.99+	1.3	250	1?0						60	79	61	61	70	63		621

4.4.1

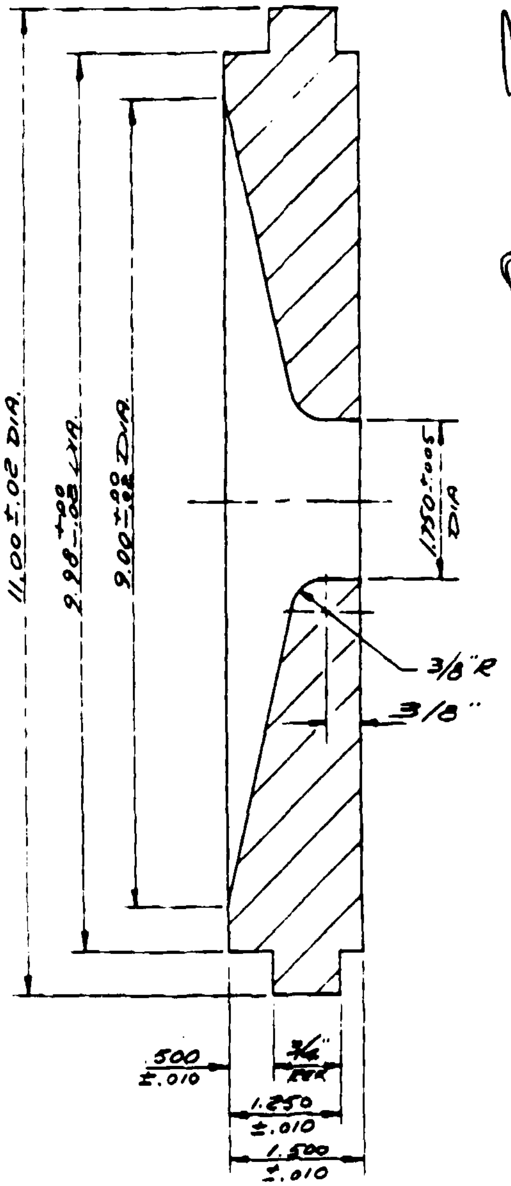
4.4



ULE DOWNDRAW FURNACE
Dry Run, 5/22 to 5/23/84
Temperature (C)
(Thousands)
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0
4
8
12
16
20
24
28
32
Hours into Run
TC
Orifice
Plate
T/C
ORIFICE
PLATE

To P. Smith
Fr M Sproul
6765

Orifice Plate
12822-1382



Rev.		Rev.		Rev.		Sheet 7 of 7	Date 2/84	Repair Date	Fused Silica Melter Assy SPECIFICATION:
						Bul. No.	By RCB		MELTING TECHNOLOG'
						Dwg. No. 12822-4801		Unit & Plant K84A	Canton

Rev.	Item No.	USE and DESCRIPTION	DWG. NO.	MATERIAL	REQ'D	ALLOT	ORDER	EST.	UNIT COST	TOTAL COST
	28	Susceptor Bottom	12822-1413	873 S	One		4			
		12.625" ± .020" O.D. x 11.75" ± .02" I.D.		Carbon						
		x 7.00" ± .01 LG .02								
		Purchase From:								
		Airco Carbon								
		See Item No. 14								

12/84
ID4/Sjf

Sheet 1 of 5
Generator Hours 2195?.2

Shift / Operator
11:00-07:00
07:00-03:00 Smith, Tom
03:00-11:00

ULE REMELTER LOGSHEET

DATE 6/5/84 GLASS CODE ULE - 1st run w/ glass. 7 1/2" - floor to center on stationary roll

Hrs into Run

TIME	TEMPERATURE, C.		GENERATOR OPERATION			WATER FLOW									PROTECTIVE GAS FLOWS, l/min						COMMENTS
	Orifice	Plate	Voltage Control	Kilo-watts	Power Factor	Water Pressure In	Generator-Temperature, F				Furnace-Temperature, F				Press	Gas	1	2	3	4	
							In	Trans	Gen	Coil	1	2	3	4		A or N					
10:00 A																					
10:30 A	START	UP	17.25	5	.99+	41	62	–	75	64	62	57	58	64	10	N	10	10	10	10	
10:35	Co F ITC	45°C						Faster													
10:55		61°C	17.25	5	.99+	34-40	62	60	73	64	61	53	60	65	10	↓	10	10	10	10	
11:13		106°C	inc gen volt ge. to			18															
11:15		102°C	18	6	1.0	40	61	58	75	65	62	59	62	64	10		10	10	10	10	
11:30		139°C	<18	5+	1.0	40	60	58	75	65	61	58	62	65	10		10	10	10	10	
11:40	inc gen to		19																		
11:45		159°C	19	6	.99+	38	61	58	75	65	62	58	64	65	10		10	10	10	10	
② 12:00		183°C	19	6	.99+	38	61	58	78	64	62	58	64	64	10		10	10	10	10	
12:[illegible]		219°C	19	6	.99+	38	61	58	75	63	62	58	64	64	10		10	10	10	10	
12:[illegible]		297°C	19	6	.99+	38	60	58	76	64	63	58	64	64	10		10	10	10	10	
12:45		268	19	6	.99+	35	60	58	77	64	63	55	64	64	10		10	10	10	10	
③ 13:00		293	19	6	.99+	37	60	59	77	65	62	58	64	64	10		10	10	10	10	
13:15		312	19	6	.99+	37	61	57	77	64	62	60	65	65	10		10	10	10	10	
13:30		333	19	6	.99+	37	60	58	78	65	62	60	65	65	10		10	10	10	10	
13:45		350	19	6	.99+	38	61	58	78	65	64	60	65	65	10		10	10	10	10	
	inc gen to		20																		
④ 14:00		369	20	7	.99+	39	60	60	78	65	62	60	65	64	10		10	10	10	10	
	inc to →		23																		
14:15		396	23	7	.99+	39	60		78	65	62	60	65	64	10		10	10	10	10	
	inc gen to →		24																		
14:30		432	24	10	.99+	36	62		79	68	62	60	68	64	10		10	10	10	10	
14:45		469	24	10	.995	33	62		78	68	64	62	70	64	10		10	10	10	10	
⑤ 15:00		502	24	10	.995	28	62		80	70	64	63	70	64	10		10	10	10	10	
		539	24	10	.997	36	60		79	69	64	63	70	65	10		10	10	10	10	
15:30		565	24	10	.998	35	60		79	69	64	63	71	64	10		10	10	10	10	1550 G-3 to 15
15:45		592	24	10	.999	36	60		80	69	64	63	71	63	10		10	10	10	10	
⑥ 16:00		615	24	10	.999	35	61		80	69	65	63	72	64	10		10	10	15	10	
		638	24	10	.999	33	61		80	69	66	64	73	64	10		10	10	15	10	
30		653	22	0.8	.999	32	60		80	70	66	64	73	66	10		10	10	15	10	
1645		660	22	.875	1	32	62	60	80	70	66	65	74	66	10		10	10	16	10	

Sheet 2 of 5
Generator Hours 21,965.8

Shift
11:00-07:00
07:00-03:00
03:00-11:00

Operator Felt

ULE REMELTER LOGSHEET

DATE 6-5-84 GLASS CODE ULE

	TIME	TEMPERATURE, C.		GENERATOR OPERATION			WATER FLOW									PROTECTIVE GAS FLOWS, l/min						COMMENTS
		Orifice	Plate	Voltage Control	Kilo-watts	Power Factor	Water Pressure In	Generator-Temperature, F In	Trans	Gen	Coil	Furnace-Temperature, F 1	2	3	4	Press	Gas A or N	1	2	3	4	
7	1700		668	21 1/2	08	999	31	61	70	80	70	64	63	72	64	10		10	10	15	10	
	1715		672	21	07	1.0	31	61	✓	78	68	65	63	72	64	10		10	10	16	10	
	1730		675	21	07	1.0	31	60	✓	80	68	65	63	72	64	10		10	10	16	10	
	1745		678	21	07	1.0	31	60	✓	80	68	66	65	74	65	10		10	16	16	10	
8	1800		680	20 1/2	07	1.0	31	60	✓	81	70	66	65	74	64	10		10	10	16	10	
	1815		680	20 1/2	07	1.0	28	61	✓	82	70	65	65	74	64	10		10	10	16	10	
	1830		680	20 1/2	07	1.0	25	62	✓	82	71	67	67	76	64	10		10	10	16	10	
	1845		680	20 1/2	07	1.0	23	62	✓	84	72	67	67	76	64	10		10	10	16	10	
9	1900		681	20 1/2	07	1.0	20 1/2	62	✓	84	74	72	71	84	66	10		10	10	16	10	
	1915		680	20 1/2	07	1.0	21	62	✓	85	74	72	72	84	66	10		10	10	16	10	
	1930		680	20 1/2	07	1.0	20	62	✓	85	74	74	72	81	64	10		10	10	16	10	
	1945		680	20 1/2	07	1.0	20	62	✓	86	74	75	72	81	64	10		10	10	16	16	
10	2000		680	20 1/2	07	1.0	18	62	✓	86	76	78	78	86	65	10		10	10	16	[illegible]	
	2000	Increased to 25							✓													
	2015		695	25	10	.99	42	62	✓	78	72	85	90	150	65	10		10	10	16	10	GEN OVERLOAD AT 2000
	2030		715	25	10	1	43	62	70	78	76	66	62	70	62	10		10	10	16	10	RESET, CHANGED WATER
	2045		736	2.5	1.0	1	41	62	✓	76	74	65	62	70	70	10		10	10	16	10	FILTERS.
11	2100		751	25	10	1	41	62	✓	78	76	68	63	70	71	10		10	10	16	10	
	2115	830	767	25	10	1	42	62	✓	78	76	68	61	72	72	10		10	10	16	10	Pyro Readings (Recorded) 86[illegible]
	2130	832	[illegible] 780	25	1.0	1	40	62	✓	78	76	68	64	72	72	10		10	10	16	10	0
	2145	854	785	25	10	1	40	62	✓	78	74	68	62	72	70	10		10	10	16	10	79 7[illegible]
	2150	increased to		27	13	.99+	41	62	68	78	76	68	64	73	72	10		10	10	16	10	
12	2200	870	805		13	.99+	41	63	68	78	76	68	64	73	72	10		10	10	16	10	
	2215	900	828	27	13	99	40	62	✓	78	76	70	64	72	72	10		10	10	16	10	
	2230	925	850	27	14	99	37	62	✓	78	76	70	66	76	72	10		10	10	16	10	
	2245	952	875	27	14	99	36	62	69	80	76	70	64	75	70	11		10	10	16	16	
13	2300	974	890	27	14	99	35	62	✓	78	78	72	65	75	70	10		10	10	16	16	
	2315	987	927	28	14	99	36	62	✓	78	78	72	65	75	70	10		[illegible]	[illegible]	16	16	
	2315	moved voltage control To 28																				
	2330	1000	920	30	14	99 3/4	30	62		80	80	77	68	79	74	10		10	10	16	10	moved control To 29
	2345	1027	948	29	15	99	34	62		80	81	77	66	79	74	10		10	10	16	10	
14	[illegible]	1050	962	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	

Sheet 3 of 5
Generator Hours

Shift: 11:00-07:00 / 07:00-03:00 / 03:00-11:00
Operator: G.M.

ULE REMELTER LOGSHEET

DATE 6/6/34 GLASS CODE ULE

TIME	TEMPERATURE, C. Orifice	Plate	GENERATOR OPERATION Voltage Control	Kilowatts	Power Factor	WATER FLOW Water Pressure In	Generator-Temperature, F In	Trans	Gen	Coil	Furnace-Temperature, F 1	2	3	4	PROTECTIVE GAS FLOWS, l/min Press	Gas A or N	1	2	3	4	COMMENTS
0015	1070	982	30	17	.99	34	62	✓	80	72	80	70	80	76	10		10	10	16	10	MOVE CONTROL TO 30
0030	1100	1020	30	17	.99	[illegible]	[illegible]	✓	80	72	82	70	82	80	10		10	10	16	10	
0045	1124	1040	30	17	.99	[illegible]	[illegible]	✓	80	72	82	70	82	80	10		10	10	16	10	
0100	1145	1062	30	17	.99	[illegible]	[illegible]	✓	80	72	82	70	84	86	10		10	10	16	10	MOVE CONTROL TO 31
0115	1175	1087	31	18	.99	32	62	✓	80	72	84	72	86	74	10		10	10	16	10	
0130	1200	1112	31	18	.99	31	62	✓	81	72	86	72	90	74	10		10	10	16	10	
0145	1226	1140	31	18	.99	29	62	✓	81	72	86	72	84	72	10		[illegible]	[illegible]	[illegible]	10	
0200	1242	1150	31	18	.99	28	62	✓	81	74	92	72	84	72	10		10	10	16	10	MOVE CONTROL [illegible]
0215	1257	1175	32	19	.99	28	[illegible]	✓	81	74	78	72	85	72	10		10	10	16	10	[illegible]
0230	[illegible]	1195	33	21	.99	28	62	✓	81	74	80	72	86	72	10		10	10	16	10	
0245	1310	1212	[illegible]	21	.99	28	62	✓	82	76	82	74	88	75	10		10	10	16	10	
0300	1325	1232	33	21	.99	27	62	✓	82	78	86	74	90	75	10		10	10	16	10	MOVE CONTROL TO 35
0315	1350	1252	35	24	<.99	28	62	✓	82	78	92	76	92	75	10		10	10	16	10	
0330	1381	1289	35	24	<.99	34	62	✓	82	78	92	76	90	76	10		10	10	16	10	
0345	1405	1306	35	24	<.99	[illegible]	62	✓	82	78	92	76	90	76	10		[illegible]	[illegible]	[illegible]	[illegible]	MOVE CONTROL TO 37
0400	1435	1340	37	27	.985	36	62	✓	82	78	90	78	92	82	10		10	10	16	10	
0415	1451	1372	37	27	.985	34	62	✓	82	78	84	76	86	82	10		10	10	16	10	MOVE CONTROL TO 39
0430	1492	1412	39	31	.98	33	62	✓	82	80	86	78	92	86	10		10	10	16	10	
0445	1530	1457	39	31	.98	33	62	✓	82	80	92	80	86	86	10		10	10	16	10	GLASS HAS SLUMPED to Top of Orifice Plate
0500	1572	1560	39	31	.98	32	62	✓	82	82	92	82	88	74	10		10	10	16	10	
0515	1540	1570	39	31	.98	32	62	✓	82	82	84	80	82	74	10		10	10	16	10	T1445 M1410 B1305
05:30	1590	1560	39	31	.98	32	62	✓	82	82	82	80	82	72	10		10	10	16	10	BAFFLE PLATE 1450 EDGE OR PLATE 1560
0545	1590	1565	39	31	.98	32	62	✓	82	82	80	80	82	74	10		10	10	16	10	
06:00	1570	1560	39	31	.98	32	62	✓	80	82	80	80	82	74	10		10	10	16	10	GLASS AT ORIFICE
06:15																			10		1750°C IN FURNACE
06:15	1580	1550	39	31	.98																
06:17	1580	1555	40	32	.98	32	62	✓	80	82	80	80	82	72	10		10	10	10	10	
06:32	1575/1735	1570	40	32	.98	32	62	✓	80	84	80	81	84	72	10		10	10	10	10	1600°C - PAUL
06:45	1580/1735	1580	40	32	.98	32	62	✓	81	84	80	82	84	73	10		10	10	10	10	
06:55			42																		

OR TIME

Sheet 4 of 5
Generator Hours

ULE REMELTER LOGSHEET

DATE 6-6-84 GLASS CODE ULE

Shift / Operator
11:00-07:00
07:00-03:00 G. G.
03:00-11:00

TIME	TEMPERATURE, C. Orifice OR	Orifice FUR	Plate	GENERATOR OPERATION Voltage Control	Kilowatts	Power Factor	WATER FLOW Water Pressure In	Generator-Temperature, F In	Trans	Gen	Coil	Furnace-Temperature, F 1	2	3	4	PROTECTIVE GAS FLOWS, l/min Press	Gas A or N	1	2	3	4	COMMENTS
07:00	1610	—	1610	42	35	.98	29	62	✓	82	88	80	82	85	72	10		10	10	10	10	
07:15	1625	—	1625	43	35	.98	26	62	✓	86	90	80	90	90	75	10		10	10	10	10	
07:30	1625		1625	42	34	.98	30	63	✓	85	90	80	82	86	72	10		10	10	10	10	
07:45	1630		1630	42	34	.93	27	65	✓	86	90	85	85	85	75	10		10	10	10	10	
07:49	inc gen to			43																		
08:00	1650		1650	43	34	.98	27	62	✓							10		10	10	10	10	
08:0[illegible]	inc gen to			44	(trying to start pull)																	
08:16	2" pull in 53.4 sec				@ 32 pull reading; turned down to 8° = 2.25"/min or 134.8"/hour or 11.2'/hour																	
08:23	inc gen to			45																		
08:31	[illegible] pull [illegible] then 24																					
08:35	pull timed @ 2" in 2.374 min = .76"/min or 45.7"/hour or 3.8'/hour																					
	inc gen to			46																		
08:38	inc gen to			48																		
08:45	cane broke - fused new rod to cane to pull																					
08:54	inc gen volt			49																		
08:56	cane broke																					
09:00				49	46	.97	25	65	✓	89	95	81	80	88	86	10		10	10	28	10	
09:1[illegible]	cane [illegible]																					
09:13	inc gen volt to			51																		
09:15				51	50	.97	24	65	✓	90	100	80	80	82	80	10		10	11	27	10	
[illegible]	1690		[illegible]	[illegible]																		
09:[illegible]	[illegible]			[illegible] glass [illegible]																		
[illegible]			1150																			1175 ROOT
09:50	=		=	51	50	.97	23	65	✓	90	95	81	80	81	80	10		10	11	27	10	1650 [illegible]
09:52	TURNED GEN VOLTAGE DOWN TO 25																					1[illegible]
10:15	1480																					1960 [illegible]
10:3[illegible]	1365																					[illegible]
10:45	1260																				10:45 P	21953.6 gen hrs
11:10	1165																					
11:51	1070																					

Sheet 5 of 5
Generator Hours

Shift — Operator
11:00-07:00
07:00-03:00
03:00-11:00

ULE REMELTER LOGSHEET

DATE ______ GLASS CODE ______

TIME	TEMPERATURE, C.		GENERATOR OPERATION			WATER FLOW									PROTECTIVE GAS FLOWS, l/min						COMMENTS
	Orifice	Plate	Voltage Control	Kilo-watts	Power Factor	Water Pressure In	Generator-Temperature, F				Furnace-Temperature, F				Press	Gas	1	2	3	4	
							In	Trans	Gen	Coil	1	2	3	4		A or N					
11:30	985																				
11:45	940																				
11:55	914																				
12:15	860																				
12:30	795																				

TOTAL GEN HOURS - SHUTDOWN READING - 21983.7
INITIAL READING - 21959.2
TOTAL 24.5 TOTAL

Sheet 1 of 4
Generator Hours 21983.7

ULE DOWNDRAW LOGSHEET

Shift — Operator
11:00-07:00
07:00-03:00
03:00-11:00

DATE 6/19/84 GLASS CODE

2nd run with glass 6/19-6/20

TIME	TEMPERATURE, C.					GENERATOR OPERATION			WATER FLOW								PROTECTIVE GAS FLOWS, l/min						COMMENTS
	OPTICAL PYRO			LAND CYCLOPS PYRO		Voltage Control	Kilo-watts	Power Factor	Water Pressure	Generator-Temperature, F			Furnace-Temperature, F				Press	Gas	1	2	3	4	
	Orifice	Plate	Top	Orifice	Top				In	In	Gen	Coil	1	2	3	4		A or N					
15:00	36°	Type K	-CrAl														8	N	10	4	4	10	
15:30	44					17.25	5	1.0	38	70	80	74	71	67	67	68	10	N	10	10	14	10	
15:45	83					17.25	5	1.0	38	70	81	72	71	70	70	70	10	N	10	10	10	10	
16:00	115					17.25	5	1.0	33	71	83	74	71	68	69	69	10	N	10	10	10	10	
16:15	146					18.0	5	1.0	36	71	85	75	71	69	70	70	10	N	10	10	10	10	
16:30	178					18.0	5	1.0	32	71	86	75	71	68	70	70	10	N	10	10	10	10	
16:45	201					18.0	5	1.0	32	71	82	76	72	67	69	69	10	N	10	10	10	10	
17:00	233					19.0	5	1.0	32	71	89	76	71	70	70	70	10	N	10	10	10	10	
17:15	263					19.0	5	1.0	32	71	89	77	71	70	71	70	10	N	10	10	10	10	
17:30	290					19.0	5	1.0	30	71	89	78	71	70	70	70	10	N	10	10	10	10	
17:45	314					19.0	5	1.0	32	71	90	78	71	70	70	70	10	N	10	10	10	10	
18:00	335					19.2	5	1.0	31	71	88	76	72	70	71	70	10	N	12	10	10	12	
18:15	355					19.0	5	1.0	31	71	88	76	71	69	71	69	10	N	10	10	10	10	
18:30	372					19.0	5	1.0	31	71	88	76	72	72	72	69	10	N	10	10	10	10	
18:45	390					19.0	5	1.0	32	71	90	79	71	70	71	70	10	N	10	10	10	10	
19:00	407					20.0	6	1.0	33	71	90	79	72	70	71	70	10	N	10	10	10	10	
19:15	435					23.0	8	.99	32	71	85	79	71	70	71	70	10	N	10	10	10	10	
19:30	443					24.0	10	.98	34	71	85	80	71	70	71	70	10	N	10	10	10	10	
19:45	473					24.0	10	.98	34	71	85	80	71	70	71	70	10	N	10	10	10	10	
20:00	515					24.0	10	.98	32	71	85	80	71	70	71	70	10	N	10	10	10	10	
20:15	553					24.0	10	.98	35	71	84	80	72	69	72	69	10	N	10	10	10	10	
20:30	573					24.0	10	.98	36	71	84	79	72	69	73	69	10	N	10	10	10	10	
20:45	615					24.0	10	.98	36	71	82	80	71	70	72	70	10	N	10	10	10	10	
21:00	640					22.0	7.5	.99	38	71	82	80	71	70	72	70	10	N	10	10	10	10	
21:15	657					22.0	7.5	.99	33	71	82	80	71	70	73	70	10	N	10	10	10	10	
21:30	667					22.0	7.5	.99	42	71	81	80	71	70	72	70	10	N	10	10	10	10	
21:45	677			Cyclops		22.0	7.5	.99	42	71	81	80	71	70	72	70	10	N	10	10	10	10	
22:00	687			723		21.0	6.0	.99	40	71	81	80	71	70	72	70	10	N	10	10	10	10	
22:15	692					21.0	6.0	.99	40	71	82	79	72	71	73	69	10	N	10	10	10	10	

Sheet 2 of 4
Generator Hours [illegible]

ULE DOWNDRAW LOGSHEET

Shift — Operator
11:00-07:00 [illegible]
07:00-03:00
03:00-11:00

DATE 6/19/84 GLASS CODE ULE

TIME	TEMPERATURE, C.					GENERATOR OPERATION			WATER FLOW								PROTECTIVE GAS FLOWS, l/min						COMMENTS
	OPTICAL PYRO			LAND CYCLOPS PYRO		Voltage Control	Kilo-watts	Power Factor	Water Pressure	Generator-Temperature, F			Furnace-Temperature, F				Press	Gas	1	2	3	4	
	Orifice	Plate	Top	Orifice	Top				In	In	Gen	Coil	1	2	3	4		A or N					
22:20																		A					
22:30	695			732		21.0	6	.99	33	71	84	79	71	69	73	69	10	A	10	10	10	10	Switched to ARGON 10791 to L/min
22:45	700			732		21.0	6	.99	37	71	81	80	71	70	73	70	10	A	10	10	10	10	
23:00	707			740		21.0	6	1	46	71	82	80	72	70	74	68	10	A	[illegible]	[illegible]	[illegible]	[illegible]	
23:15	711			752		21.0	6	1	46	72	82	80	72	70	74	70	10	A	10	10	10	10	
23:30	716			757		21.0	6	1	48	72	82	80	72	70	74	78	10	A	10	10	10	10	
23:45	721			762		21.0	6	1	48	72	82	80	72	70	75	70	10	A	10	10	10	10	
24:00	727			768		21.0	6	1	46	72	82	80	72	70	74	70	10	A	10	10	10	10	
0:15	731			770		21.0	6	1	46	70	82	80	72	72	[illegible]	70	10	A	10	10	10	10	Made move on GCV
00:30	749			794		26.0	12	1	47	71	82	80	74	72	76	70	10	A	10	10	10	10	To 26
00:45	830 LAN	786 TC		827		26	12	1	47	70	82	80	72	72	76	70	10	A	10	10	10	10	
01:00	852	819		860		26	12	1	49	70	80	80	72	72	75	70	10	A	10	10	10	10	Pulled TC
1:15	886	847		894		26	12	1	48	72	82	81	72	72	76	68	10	A	10	10	10	10	
1:30	911	865		920		26	12	1	48	72	82	82	74	72	78	68	10	A	10	10	10	10	
1:45	945	890		952		26	12	1	48	71	82	82	74	72	76	70	10	A	10	10	10	10	
2:00	966	925		974		28	13	.99	47	71	82	78	74	72	76	70	10	A	10	10	10	10	Moving [illegible] Control
2:15	992	954		1003		28	15	.99	46	72	81	78	74	72	78	70	10	A		10	10	10	
2:30	1020	964		1037		29	[illegible]	.99	46	71	82	[illegible]	75	72	76	70	10	A	10	10	10	10	Moved [illegible]
2:45	1052	995		1072		29	16	.99	47	72	82	[illegible]	76	72	76	70	10	A	10	10	10	10	
3:00	1083	1020		1107	55 wire	29	16	.99	46	72	82	78	75	72	76	70	10	A	10	10	10	10	
3:15	1115	1050		1140		29	16	.99	48	71	82	78	76	72	74	70	10	A	10	10	10	10	Set on [illegible] filter Cyclops
3:30	1148	1080		1160		30	17	.99	46	71	82	[illegible]	76	73	77	70	10	A	10	10	10	10	and middle scale LAN
3:45	1173	1101	1216	1187	1101	33	22	.99	47	70	82	82	76	72	72	70	10	A	10	10	10	[illegible]	There is a -10° difference
[illegible]	1205	1130		1232		[illegible]	[illegible]	.99	48	70	82	[illegible]	76	74	[illegible]	70	10	A	[illegible]	[illegible]	[illegible]	[illegible]	with and [illegible] filter at 1150
[illegible]	[illegible]	[illegible]		1230		33	[illegible]	[illegible]	[illegible]	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	A	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	1322	[illegible]		[illegible]		[illegible]	[illegible]	.99	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
5:20	[illegible]	[illegible]		1400		[illegible]	[illegible]	.99	46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	1408	[illegible]		1422		36	25	.99	46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	A	[illegible]	[illegible]	[illegible]	10	
[illegible]	1438	[illegible]		1471		36	[illegible]	.99	48	[illegible]	82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]			[illegible]		[illegible]	36	.99	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

54

Sheet 3 of 4
Generator Hours 21118

ULE DOWNDRAW LOGSHEET

Shift — Operator
11:00-07:00
07:00-03:00
03:00-11:00

DATE 6/20/84 GLASS CODE ULE

TIME	TEMPERATURE, C. OPTICAL PYRO Orifice	OPTICAL PYRO Plate	OPTICAL PYRO Top	LAND CYCLOPS PYRO Orifice	LAND CYCLOPS PYRO Top	GENERATOR OPERATION Voltage Control	Kilo-watts	Power Factor	WATER FLOW Water Pressure In	Generator-Temperature, F In	Generator-Temperature, F Gen	Generator-Temperature, F Coil	Furnace-Temperature, F 1	Furnace-Temperature, F 2	Furnace-Temperature, F 3	Furnace-Temperature, F 4	PROTECTIVE GAS FLOWS, l/min Press	Gas A or N	1	2	3	4	COMMENTS
06:30	1463	1425		1543		39	30	.98	46	71	82	82	79	76	78	70	10	A	10	10	10	10	
[illegible]				[illegible]	1381	1451 [illegible]		[illegible]															
[illegible]	1500	1472		1590		39	30	.98	47	71	82	84	78	76	78	70	12	A	10	10	10	10	
[illegible]	1525	1490	[illegible]	[illegible]																			
[illegible]	1520	1500		1575		39	30	[illegible]	46	71	82	84	78	76	78	70	12	A	10	10	10	10	
06:45	1525	[illegible]		1583		43	37	[illegible]	47	78	84	[illegible]	83	[illegible]	[illegible]	[illegible]	10	A	[illegible]	[illegible]	[illegible]	[illegible]	Glass Hellway through [illegible]
[illegible]	[illegible]	[illegible]		1610		45	41	.92	40	71	84	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12	A	10	10	10	10	
07:15		1630		1668		42	35	.98	40	[illegible]	[illegible]	[illegible]	80	76	80	68	10	A	10	10	10	10	
07:30		1645		1676		42	35	.98	40	71	82	88	[illegible]	76	80	68	10	A	10	10	10	10	
07:45		1625	[illegible]	[illegible]	[illegible]	42	35	.98	43	71	82	88	80	76	80	68	10	A	10	10	10	10	
[illegible]			[illegible]																				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	m14																		
[illegible]						42	35	.98	41	71	82	88	80	76	80	68	10	A	10	10	10	10	
[illegible]	[illegible]	15.31 [illegible]																					
[illegible]						41																	316 on speed control
[illegible]						41	33	.93	42	71	90	86	82	82	82	68	10	A	10	[illegible]	[illegible]	10	Roei - 1744
																							O-Plate 1698
																							M-T - 1608
																							M - 1555
																							B - 1380
08:20	2" in 12 [illegible] sec @ 22																						[illegible] speed to 80
[illegible]						41	33	.93	40	71	[illegible]	86	82	82	82	68	[illegible]	A	[illegible]	[illegible]	[illegible]	10	Glass [illegible]
[illegible]	2 [illegible] 8.44 sec @ 22																						Glass @ [illegible]
[illegible]						[illegible]	3[illegible]	[illegible]	[illegible]	[illegible]	92	[illegible]	[illegible]	82	84	[illegible]	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	Gas/Surface [illegible]
[illegible]	Grake		[illegible]																				
[illegible]			1543			31																	
[illegible]						31	31	[illegible]	3[illegible]	71	[illegible]	[illegible]	84	82	84	[illegible]	12	A	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]					[illegible]	[illegible]		11.23 sec	[illegible]													
[illegible]						31	31	[illegible]	[illegible]	71	[illegible]	[illegible]	84	82	84	[illegible]	[illegible]	A	[illegible]	[illegible]	[illegible]	9	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																			
9:18	[illegible]		[illegible]																				

Sheet 4 of 4
Generator Hours 22,004.9(?)

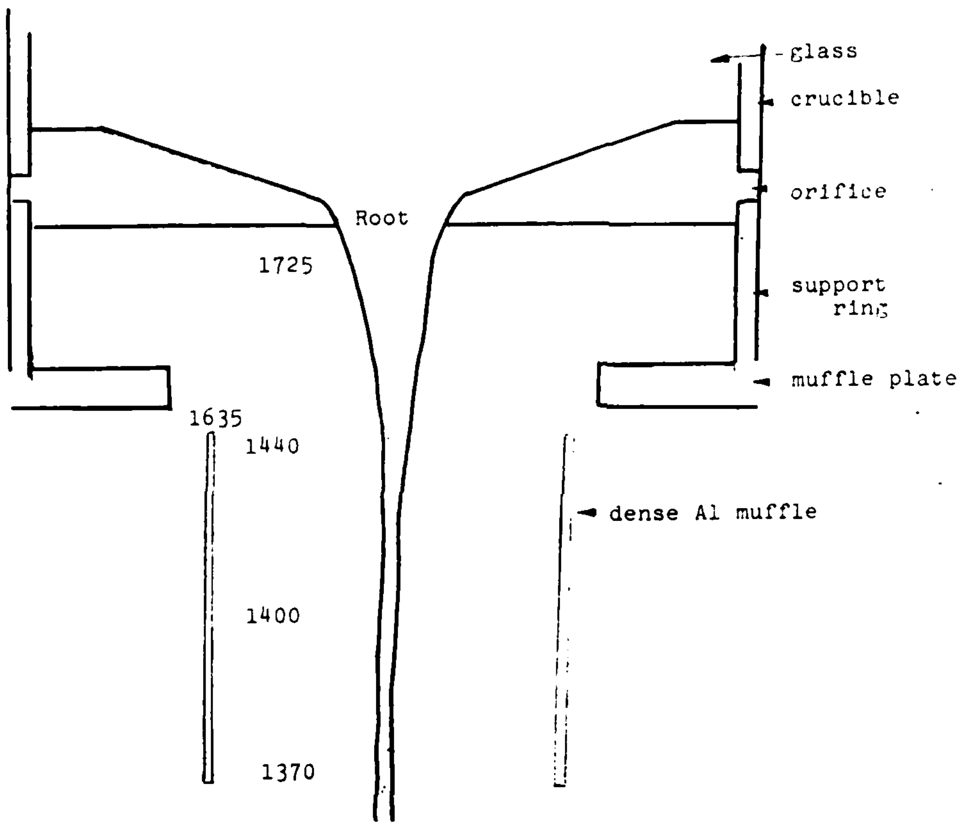
ULE DOWNDRAW LOGSHEET

Shift / Operator
11:00-07:00 ____
07:00-03:00 ____
03:00-11:00 ____

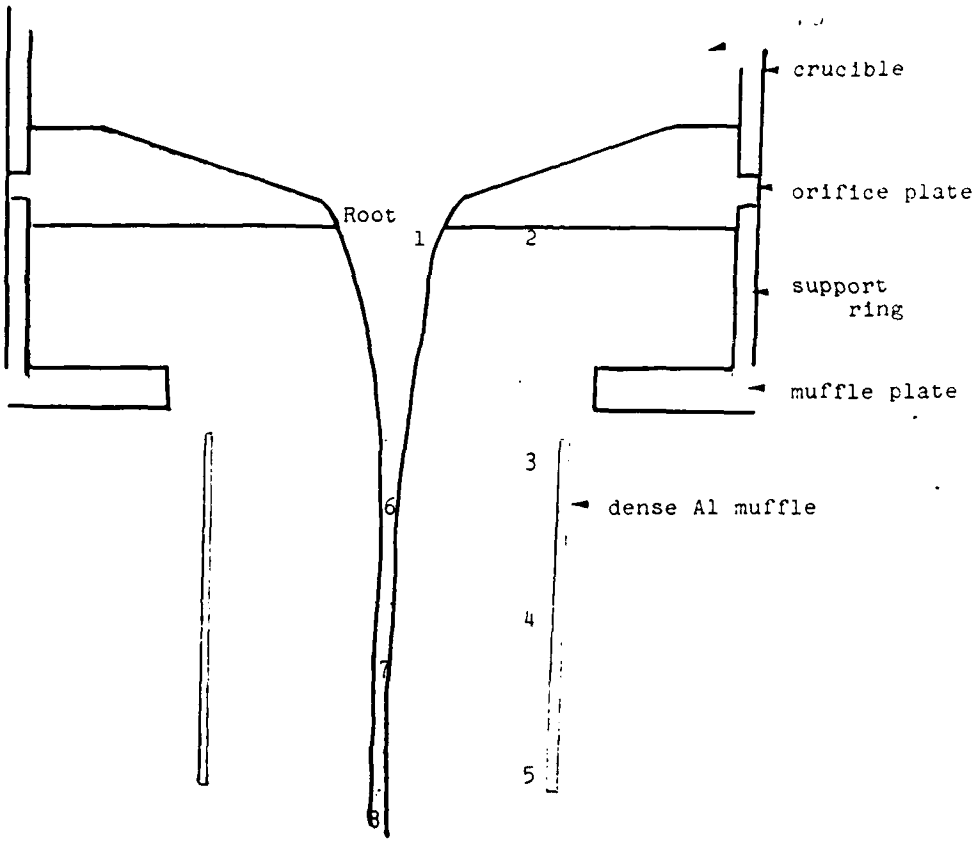
DATE ______ GLASS CODE ______

TIME	TEMPERATURE, C. — OPTICAL PYRO — Orifice	Plate	Top	LAND CYCLOPS PYRO — Orifice	Top	GENERATOR OPERATION — Voltage Control	Kilo-watts	Power Factor	WATER FLOW — Water Pressure In	Generator-Temperature, F — In	Gen	Coil	Furnace-Temperature, F — 1	2	3	4	PROTECTIVE GAS FLOWS, l/min — Press	Gas A or N	1	2	3	4	COMMENTS
9:20	ARGON BACK ON																						
9:20				1716																			
09.12	sic pull rate to 40				2" in 5.46 sec repeat 2" in 5.3 sec @ 40																		
9:50	"	"	"	" 50	2" in 4.98 sec, [illegible] 8" in 16.39 and 8" in 17.99 sec; ave 12.2 sec @ piece 55																		
[illegible]		[illegible]		1727		39	31	58	36	74	64	79	92	90	72	72	10	A	10	[illegible]	[illegible]	[illegible]	
10:03	sic pull to 60				8" in 15.13 sec and 14.97 ave 15 @ piece 62																		
10:15				1705	110°C on glass - approx 24 [illegible] (piece 64)																		
[illegible]	sic pull to 70				8" in 15.[illegible] sec and @ piece 74 - slipping on roller																		
	drive pressure from 5 to 15 psi 8" in 10.82 sec																						
[illegible]				1247		39	32	99	36	75[illegible]	86	72	80	82	84	72	12	A	12	12	12	12	glass rod has bumps
[illegible]	decreased pull to 80 dec roller pressure to																						
11:00				1712		39	[illegible]	98	34	75	75	70	80	80	84	68	10	A	10	10	10	10	
11:04	pull rate @ 20				2" in 15.7 sec @ piece 91																		
[illegible]	pull rate @ 0				@ piece 9[illegible]																		[illegible]
11:39	DECREASED POWER TO 0																						
11:[illegible]				1699																			[illegible] of machine
11:31	GENERATOR OFF					gen hrs 22004.9 -21983.7																	
11:45				1491																			
							20.3																
12:00				1226																			
12:15				1173																			
12:30				1019																			
12:50				928	[illegible]																		

Temperature Readings at Furnace Bottom; Run 1
6/6/84 10 a.m.



Temperature Readings at Furnace Bottom; Run 2
6/20/84



Time	LOCATION 1	2	3	4	5	6	7	8
0850	1691	1732	1606	1373	1330	1452	1339	959
0937	1742	1662	1589	1495	1290	1454	1246	971
1021	1747	1657	1620	1518	1401	1453	1317	1185

ULE DOWNDRAW FURNACE

SHUTDOWN PROCEDURE

1. Turn generator voltage control to zero percent.

2. Shut of main line contactor.

3. Shut off generator field.

4. Push and hold motor generator starter button until starter relay drops put (about 10 seconds).

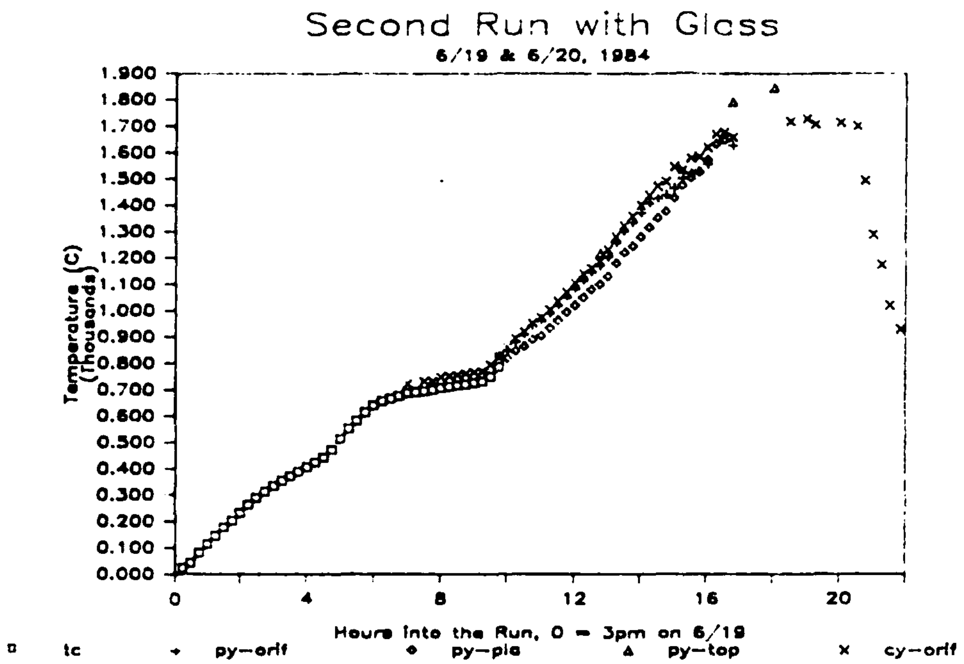
5. Leave gas and water on to cool furnace.

Gas Settings

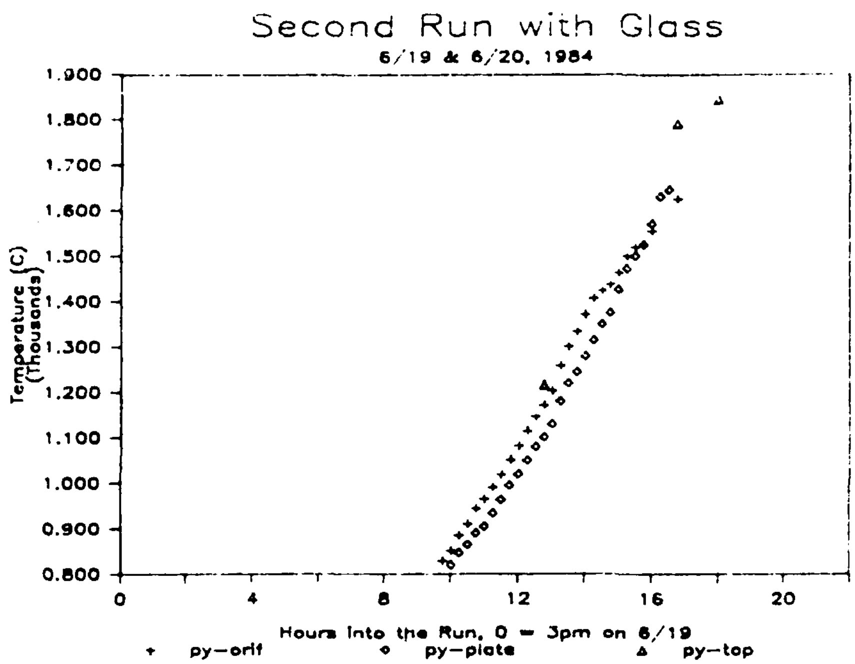
Nitrogen pressure at 10
Set each flow meter to 5l/min
Shut pressure and flow off after 4 hours.

Water

Leave water on till furnace is cool.
(12 hour minimum).



Second Run with Glass
6/19 & 6/20, 1984
Temperature (C)
(Thousands)
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0
4
8
12
16
20
Hours into the Run, 0 = 3pm on 6/19
tc
py-orif
py-pla
py-top
cy-orif


Second Run with Glass
6/19 & 6/20, 1984
Temperature (C)
(Thousands)
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
0
4
8
12
16
20
Hours Into the Run, 0 = 3pm on 6/19
+ py-orif
◇ py-plate
Δ py-top

1. Introduction

A block of ULE™ titanium silicate 6" x 6" x 4" was selected for study. Three 2" diameter x 4" long cylindrical slugs were core drilled from this block and induction remelted for ½ hour at 1650°C. on three separate furnace runs. Following these remelting thermal cycles, chosen to simulate remelting for redrawing, all three were annealed together on the ULE™ standard anneal.

The purpose of exposing ULE™ to remelt thermal conditions is to determine if any significant change occurs in key physical properties. Large or erratic changes may influence decisions on proceeding with the remelting and drawing facility at Canton.

2. Sample Plan

From each of the three cylindrical slugs these pieces were cut for the purpose stated:

(a) a 1/8" x 3 7/8" x 1 7/8" piece to be fritted to two identical parts from the original block to form a symmetrical sandwich seal.

(b) a 3/8" diameter x 4" rod for superdilatometer 5 to 35°C. thermal expansion coefficient. An identical rod was taken from the original block as well.

(c) a 1/10" x 1/10" x 3" beam for beam bending annealing and strain point. An identical beam was taken from the original block.

3. Experimental Results

3.1 Symmetrical Sandwich Seals

Through photoelastic analysis the symmetrical sandwich seal yields the difference in expansion from the setting point (925°C) to 25°C. No significant differences are found.

Cylindrical Slug No.	Block Minus Slug $\Delta\alpha$, ppb/°C
1	+ 0.36
2	+ 4.65
3	- 0.90

REPORT

EVALUATION OF THERMAL EXPANSION AND VISCOSITY CHANGES IN ULE™ TITANIUM SILICATE DUE TO THERMAL HISTORY SIMULATION OF REMELT FOR REDRAW.

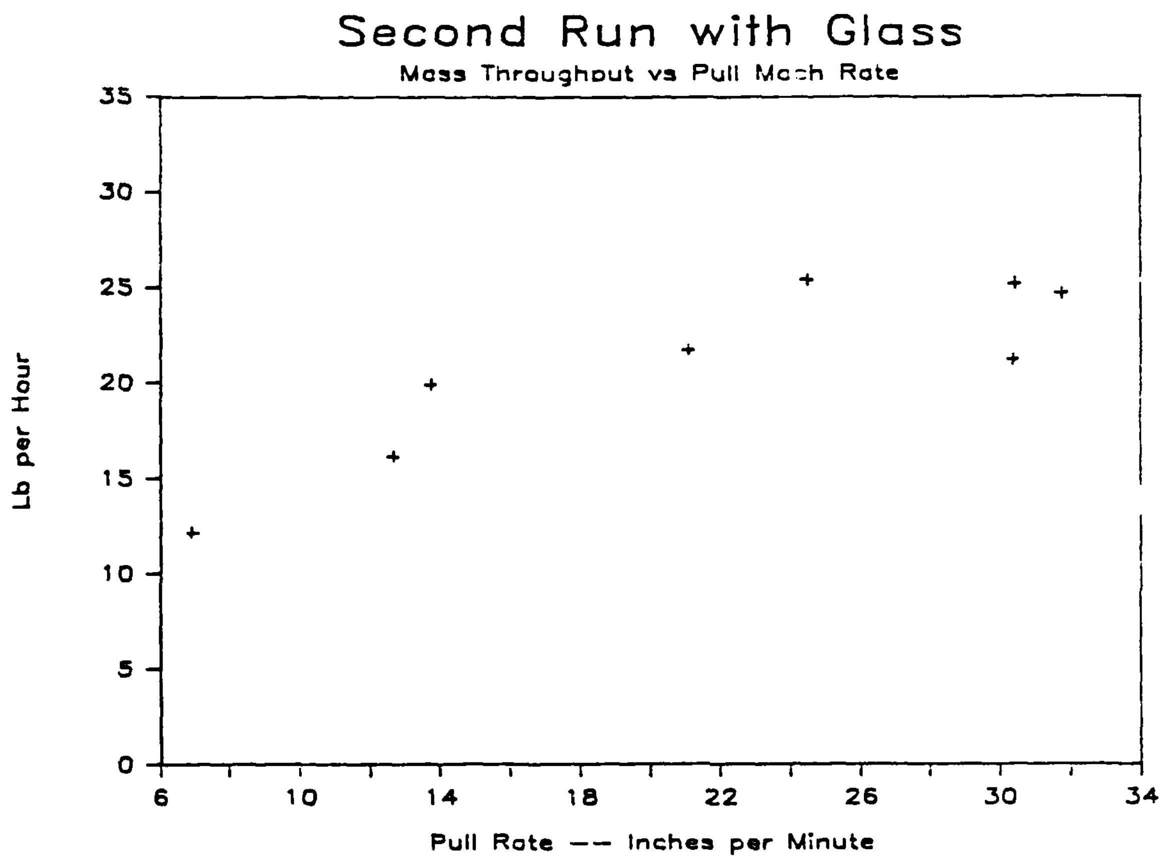
Contract No. F30602-83-C-0121

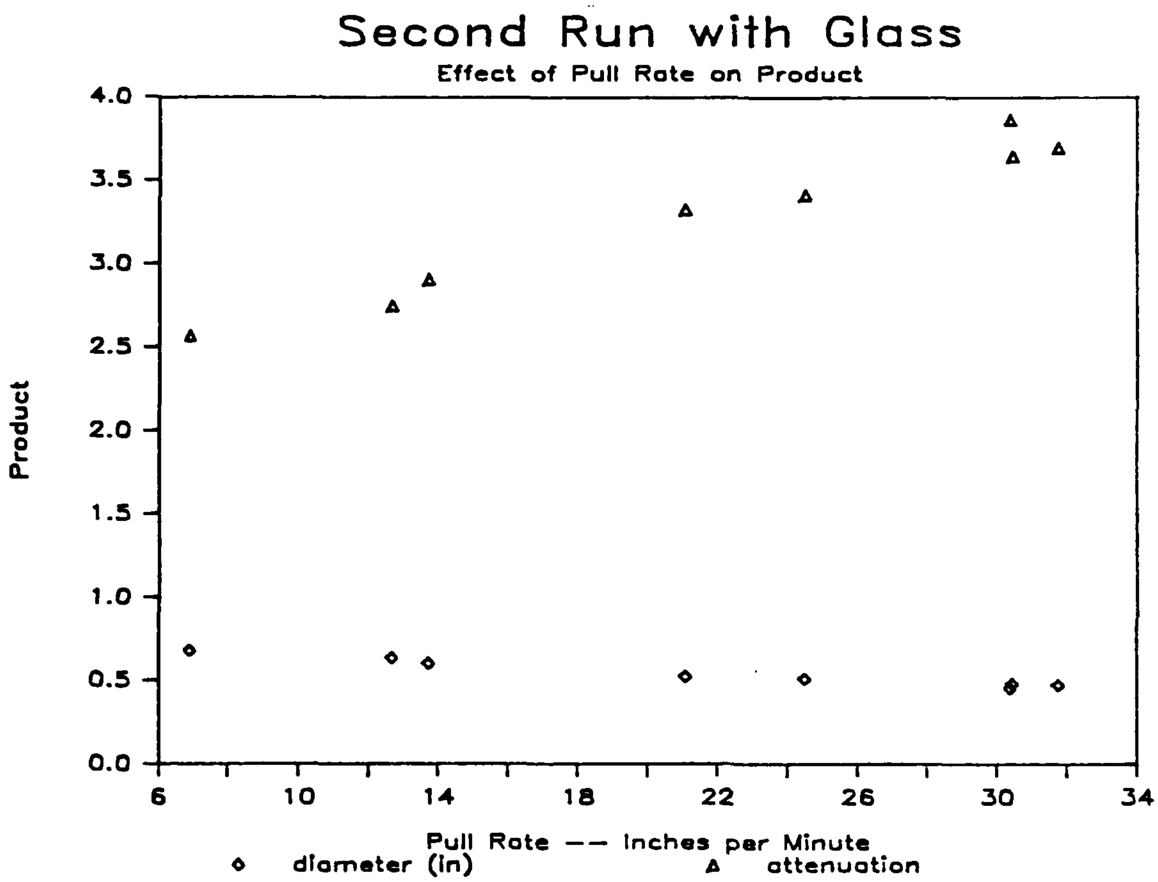
H. E. Hagy
Corning Glass Works
Research & Development Division

September 28, 1983

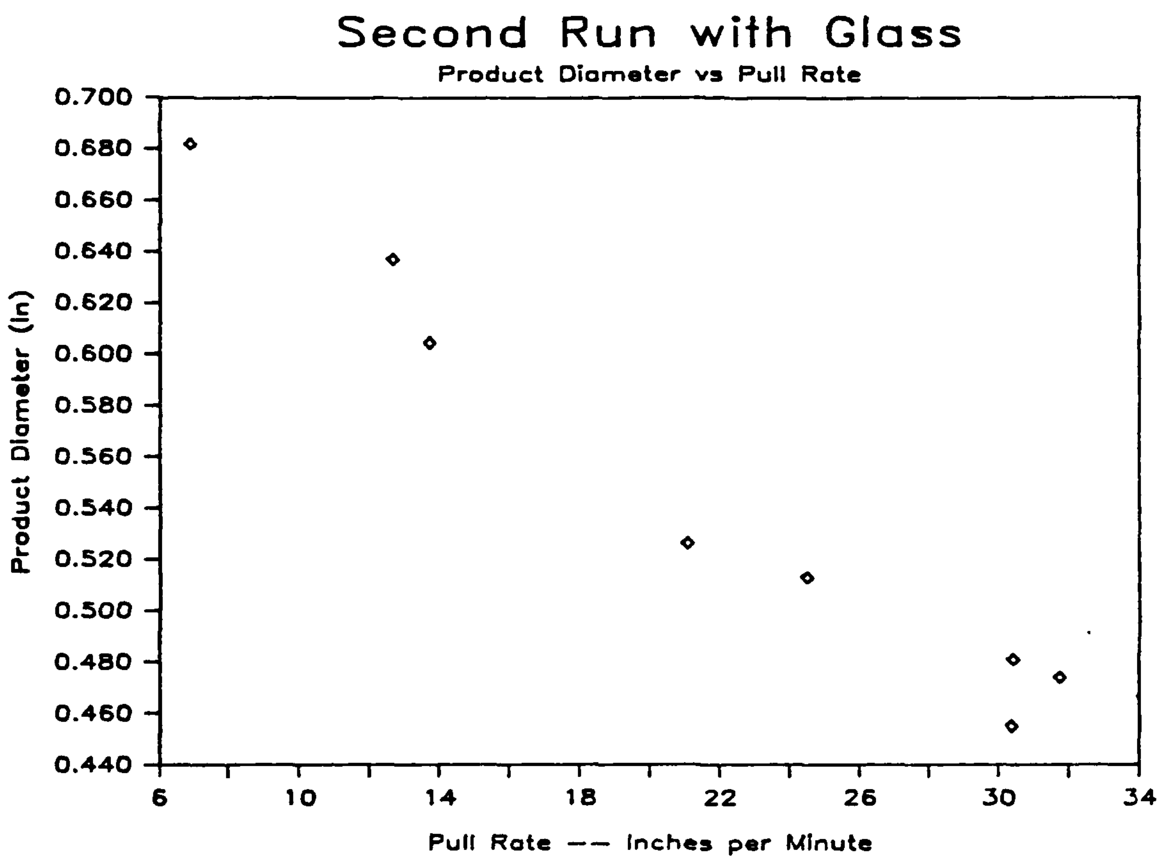
Run 2 With Glass - Linear Regressions

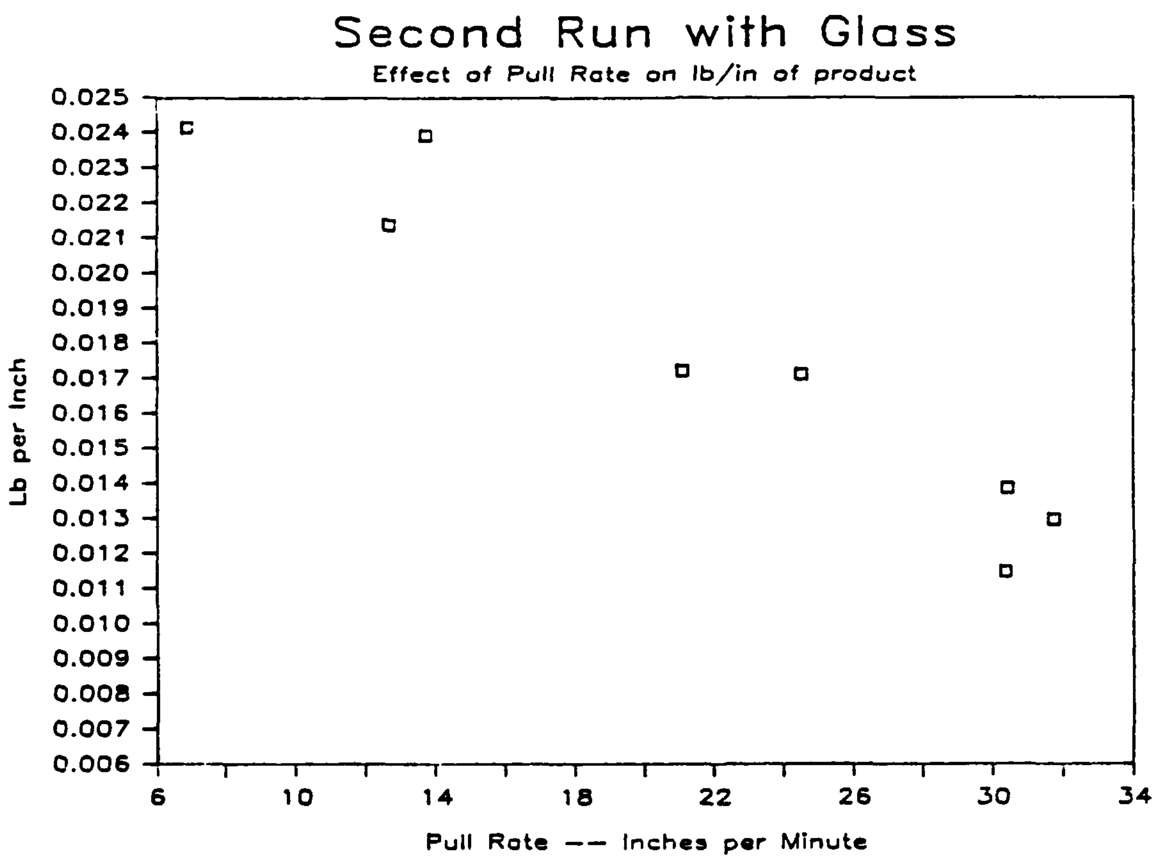
	T-ratio	Std. Dev.	R^2 Value
Pull Rate = 4.43 + .441 (pot setting)	-	3.359	87.3%
Pounds In = .0284 - .0005 (pull rate)	-7.83	.001598	89.6%
Mass Thru = 11.6 + .433 (pull rate)	4.38	2.463	72.2%
Prod. Diameter=.734 - .0088 (pull rate)	-13.27	.01646	96.2%
Attenuation = 2.24 + .0484(pull rate)	11.94	.1010	95.3%


Second Run with Glass
Mass Throughput vs Pull Mach Rate
Lb per Hour
Pull Rate —— Inches per Minute
0
5
10
15
20
25
30
35
6
10
14
18
22
26
30
34



Second Run with Glass
Effect of Pull Rate on Product
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Product
6
10
14
18
22
26
30
34
Pull Rate -- Inches per Minute
diameter (in)
attenuation


Second Run with Glass
Product Diameter vs Pull Rate
Product Diameter (In)
0.700
0.680
0.660
0.640
0.620
0.600
0.580
0.560
0.540
0.520
0.500
0.480
0.460
0.440
6
10
14
18
22
26
30
34
Pull Rate -- Inches per Minute

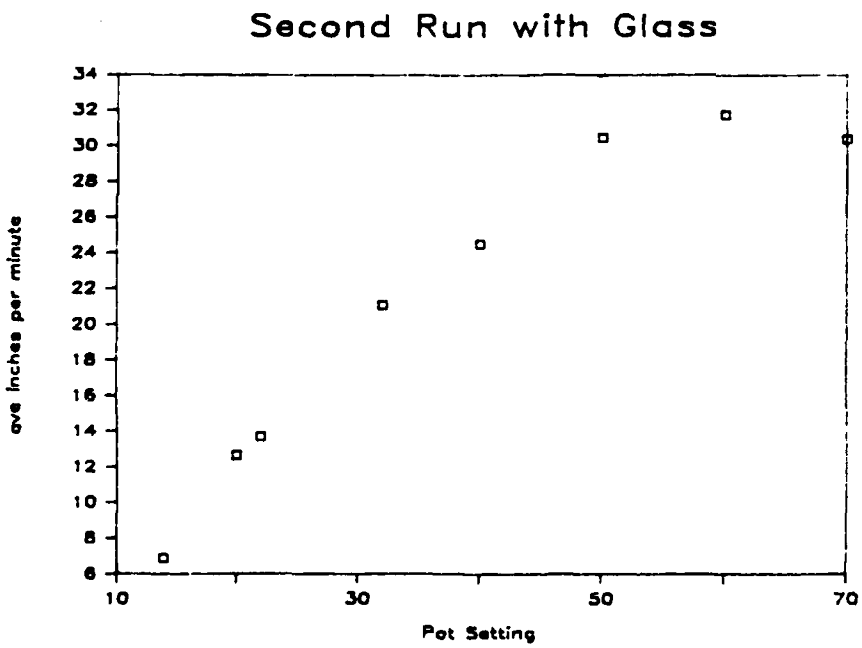

Second Run with Glass
Effect of Pull Rate on lb/in of product
Lb per Inch
0.025
0.024
0.023
0.022
0.021
0.020
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
6
10
14
18
22
26
30
34
Pull Rate -- Inches per Minute

Pull Rate (in/min)

Pot Setting	Calculated	Timed	Average
14	-	6.9	6.9
20	14.2	11.1	12.7
22	14.7	12.7	13.7
32	22.2	20.0	21.1
40	26.7	22.2	24.5
50	32.0	28.9	30.4
60	31.5	31.7	31.7
70	28.8	31.9	30.7

Second Run with Glass

pot setting	Ave lb/in	Ave in/min	Ave thruput (lb/hr)	Ave diameter (in)	Ave atten
14	0.024	6.9	12.2	0.682	2.6
20	0.021	12.7	16.2	0.637	2.8
22	0.024	13.7	19.9	0.604	2.9
32	0.017	21.1	21.8	0.526	3.3
40	0.017	24.5	25.4	0.513	3.4
50	0.014	30.4	25.2	0.481	3.6
60	0.013	31.7	24.7	0.474	3.7
70	0.011	30.3	21.2	0.455	3.9


Second Run with Glass
ave inches per minute
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
10
30
50
70
Pot Setting

CAKE MEASUREMENTS-SECOND RUN W/ GLASS

109	1128	44	[illegible]	[illegible]	[illegible]	[illegible]
109	1129	45	[illegible]	45	[illegible]	4.18
111	[illegible]	57	[illegible]	44	[illegible]	[illegible]
111	1131	44	[illegible]	[illegible]	[illegible]	[illegible]
112	1132	37	[illegible]	35	[illegible]	4.66
average					[illegible]	[illegible]
clear subtotal		9271	20.4	[illegible]		
other subtotal		20204	44.5	[illegible]		
total		29475	[illegible]	[illegible]		
		grams	pounds	inches		
				or		
				[illegible]		
				feet		

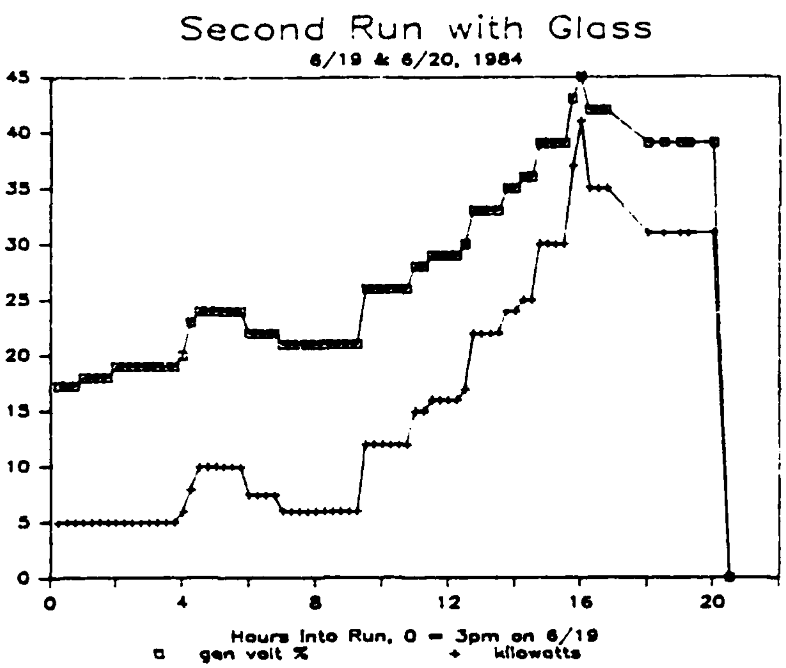
SAND MEASUREMENTS-SECOND RUN W GLASS

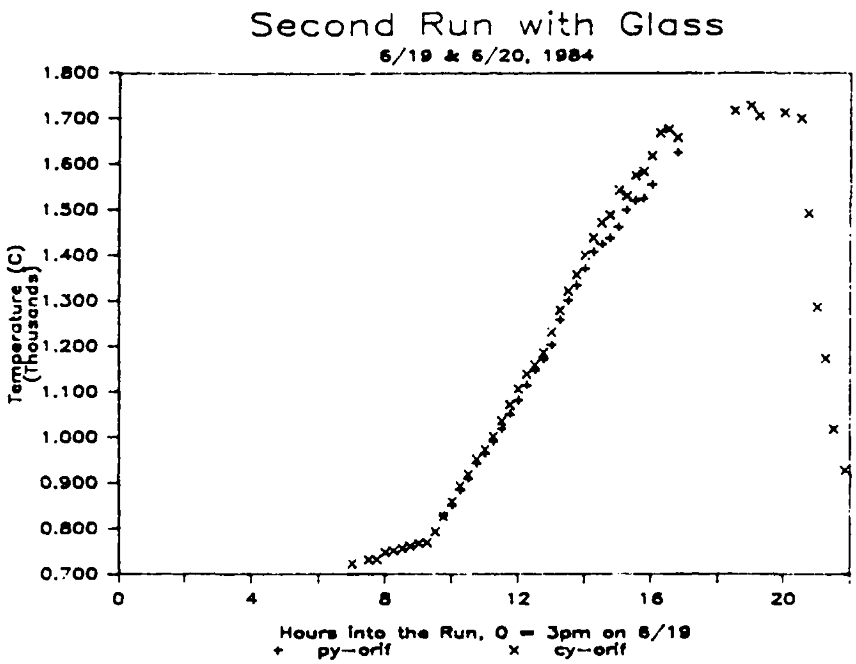
52	955	247	0.52	35	30	0.498	3.51	•
53	956	242	0.51	36		0.510	3.50	blue center with holes
54	958	228	0.51	33		0.491	3.56	
55	959	221	0.47	37		0.460	3.8	•
56	1000	214	0.45	36		0.459	3.81	
57	1001	180	0.40	31		0.478	3.66	•
58	1003	252	0.53	40	50	0.473	3.70	•
59	1004	202	0.44	34		0.471	3.72	•
60	1005	206	0.45	34		0.495	3.54	
61	1006	240	0.52	39		0.466	3.60	•
62	1007	228	0.50	37		0.479	3.65	
63	1009	210	0.46	35		0.485	3.61	
64	1010	198	0.44	36		0.451	3.88	•
65	1011	196	0.42	35		0.459	3.82	•
66	1012	204	0.45	36		0.495	3.54	•
67	1013	202	0.44	35		0.452	3.87	•
68	1014	187	0.41	33		0.469	3.74	•
69	1016	204	0.45	37		0.479	3.65	•
70	1017	225	0.50	33		0.471	3.72	•
71	1018	211	0.46	37	70	0.475	3.66	•
72	1019	216	0.48	37		0.493	3.55	•
73	1020	200	0.44	32		0.486	3.60	•
74	1021	195	0.44	36		0.481	3.64	•
75	1022	190	0.42	36		0.461	3.80	•
76	1024	220	0.48	37		0.493	3.57	•
77	1025	185	0.41	37		0.475	3.68	•
78	1025	151	0.33	34		0.420	4.17	• ; bump
79	1026	192	0.42	43		0.425	4.12	• ; bump
80	1028	194	0.41	38		0.421	4.16	• , bump
81	1032	170	0.37	37		0.411	4.27	blue; very bumpy
83	1035	157	0.35	34		0.421	4.16	•
84	1039	340	0.76	36	20			•
85	1042	337	0.74	33				•
86	1045	334	0.74	34				•
87	1048	312	0.69	32		0.640	2.73	blue; foam & bumps
87	1052	405	0.89	41				•
88	1055	355	0.78	38		0.619	2.93	•
89	1059	332	0.73	35		0.627	2.75	•
90	1101	371	0.82	39		0.602	2.91	blue; foam & ripples
91	1106	399	0.88	41		0.628	2.74	•
92	1109	423	0.93	42		0.636	2.75	•
93	1111	402	0.89	41		0.657	2.66	blue; foam to hollow
94	1112	319	0.70	35		0.666	2.63	blue; hollow
95	1114	242	0.53	34	50	0.666	2.63	•
96	1116	158	0.35	37		0.461	3.80	•
97	1117	157	0.35	36		0.517	3.38	•
98	1118	195	0.43	35		0.475	3.68	•
99	1119	195	0.43	45		0.485	3.61	•
100	1120	172	0.38	38		0.503	3.48	•
101	1121	218	0.48	48		0.515	3.40	•
102	1122	168	0.37	45		0.478	3.66	•
103	1123	126	0.28	41		0.455	3.85	•
104	1124	110	0.24	46		0.440	3.98	•
105	1125	80	0.19	38		0.445	3.93	dark; hollow
106	1126	92	0.20	45		0.430	4.07	•
107	1127	80	0.18	42		0.455	3.95	•

CANE MEASUREMENTS-SECOND RUN A GLASS

GLASS SAMPLES -RUN 2

SAMPLE NO	TIME	WEIGHT grams	pound	LENGTH inches	[illegible]	diameter	other	
1		816	1.80	26		0.655	2.67	starting plug
2		519	1.14	29	14	0.682	2.57	clear
3		386	0.85	29		0.700	2.49	"
4		423	0.94	[illegible]		0.655	2.66	" "
5		325	0.72	26		0.673	2.58	"
6		285	0.63	22		0.651	2.54	
7		[illegible]	[illegible]	[illegible]		[illegible]	2.52	
8		395	0.87	[illegible]		[illegible]	2.46	"
9		370	0.81	29		0.655	2.66	
10		335	0.74	32	22	0.633	2.75	"
11	821	322	0.71	[illegible]		0.633	2.76	"
12	824	326	0.72	[illegible]		0.629	2.75	"
13	826	335	0.74	31		0.627	2.79	"
14	839	334	0.74	31		0.619	2.83	"
15	841	322	0.71	30		0.617	2.84	"
16	843	322	0.71	30		0.619	2.83	"
17	846	325	0.72	31		0.619	2.83	"
18	848	320	0.70	31		0.616	2.84	"
19	851	331	0.73	31		0.615	2.84	"
20	852	333	0.73	31		0.617	2.84	"
21	855	351	0.77	31		0.624	2.80	
22	856	205	0.45	19		0.624	2.80	devit
23	902	360	0.79	33		0.622	2.81	"
24	904	586	1.29	46		0.507	3.45	"
24	911	379	0.83	35		0.624	2.80	
25	912	446	0.98	39		0.540	3.24	
26	914	337	0.74	34	33	0.555	3.15	"
27	915	278	0.61	35		0.537	3.26	
28	917	266	0.59	33		0.528	3.31	clear
29	919	262	0.58	34		0.525	3.33	
30	920	220	0.48	29		0.522	3.35	"
31	922	256	0.56	34		0.514	3.47	"
32	923	167	0.37	23		0.516	3.39	
33	925	264	0.58	36		0.515	3.40	
34	927	290	0.64	39		0.525	3.33	devit
35	929	252	0.56	36		0.507	3.45	blue streak
36	930	265	0.58	35		0.528	3.31	"
37	933	250	0.55	33		0.528	3.33	"
38	935	260	0.57	34		0.522	3.35	"
39	936	268	0.59	35		0.522	3.35	
40	938	216	0.48	29		0.522	3.35	"
41	940	244	0.54	31		0.536	3.26	"
42	941	302	0.67	38		0.535	3.27	"
43	943	260	0.57	32		0.537	3.26	several blue streaks
44	944	248	0.55	31		0.538	3.25	"
45	945	392	0.86	37	41	0.533	3.28	"
46	947	234	0.52	31		0.532	3.29	"
47	948	272	0.60	34		0.537	3.26	"
48	950	244	0.54	33		0.499	3.59	"
49	951	242	0.53	35		0.496	3.53	"
50	952	232	0.51	37		0.502	3.49	" ; bump
51	954	226	0.50	33		0.503	3.49	"


Second Run with Glass
6/19 & 6/20, 1984
45
40
35
30
25
20
15
10
5
0
0
4
8
12
16
20
Hours into Run, 0 = 3pm on 6/19
gen volt %
kilowatts


Second Run with Glass
6/19 & 6/20, 1984
Temperature (C)
(Thousands)
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
0.700
0
4
8
12
16
20
Hours into the Run, 0 = 3pm on 6/19
+ py-orif
× cy-orif

3.2 Beam Bending Viscometry

Measurement of annealing and strain points provides a sensitive indication of composition and/or structure change. No significant differences are indicated.

	Annealing Point, °C	Strain Point, °C
Slug No. 1	1008	897
Slug No. 2	1008	898
Slug No. 3	1009	899
Original Block	1007	896

3.3 Superdilatometer

The superdilatometer has a standard deviation of ± 5ppb/°C and is much less precise than the sandwich seals. Results are:

Cylindrical Slug No.	Block Minus Slug, ppb/°C
1	+ 2
2	+18
3	- 6

There is a slight suspicion that a real difference exists between the block and slug #2. Sandwich seals show this also.

4. Conclusion

The simulated remelt thermal cycle has negligible effect on these properties of ULE™ titanium silicate. Only slug #2 shows a small expansion difference which may well have been in the starting composition.

<u>TEST REPORT</u>

"Evaluation of Thermal Expansion
Change in ULE™ Titanium Silicate
Following Remelting and Downdrawing -
Phase I, Run 2"

H. E. Hagy
July 24, 1984

1. Introduction

Phase I, Run 2 of the remelting, downdraw program at the Canton plant produced cane ranging from ½" to 3/4" in diameter. A key question about this process is whether the thermal expansion of the ULE™ glass is altered.

Accordingly, a sandwich seal testing program was developed through the cooperative efforts of Canton and R & D personnel to answer this question. Through the use of a "standard" ULE™ of nearly the same original expansion, but not remelted, downdrawn specimens can be compared by frit sealing. Adequate sensitivity is provided at a cost far less than direct expansion measurements.

2. Standard and Downdraw Glass

2.1 Standard

The pieces representing standard unmelted glass were cut from a block, Piece #8, described on Figure 1. Expansion values on this figure are ultrasonically derived and represent the 5 to 35°C coefficient in units of ppb/°C. Standard pieces for sandwich seals, 0.080" x 0.45" x 1.5", were cut from the shaded area. Since locations of individual pieces were not documented, it is obvious from the x-axis plot that the standard has a range of expansion of 7 ppb/°C.

2.2 Downdraw Specimens

Figure 2 shows how downdraw pieces, with the same dimensions as the standard pieces, were cut from the drawn cane. Nine downdraw cane specimens described in Figure 2 were selected for study. One piece for sealing was cut from each of these nine canes.

Radial expansion profiles for the three 9½" diameter discs stacked vertically to make the furnace charge are shown in Figure 2A.

2.3 Annealing

All parts used in the sandwich seal testing were given the standard ULE™ fine anneal to normalize thermal history.

3. Sandwich Seals

Spaced sandwich seals were fritted in the geometrical configuration shown on Figure 3. U-type frit, M-14-3504, BM-82-251, was used and fired two hours at 960°C. A ride-along F-G-F wafer seal showed perfect expansion match between the frit and ULE™.

4. Experimental Method

Following sealing, the optical retardation in the central (downdraw) seal member was measured using a Friedel polarimeter. The difference in thermal expansion coefficients between standard and downdraw from the setting point (925°C) and room temperature (25°C) is given by the following equation:

$$\Delta\alpha = \frac{\lambda A F}{180\, k\, p\, E\, \Delta T} \left[1 + \frac{t_d}{2t_s}\right] 10^9 \qquad (1)$$

where:

$\Delta\alpha$ = expansion coefficient difference, ppb/°C,

λ = peak wavelength of filtered white light, 546 nm,

A = rotation of Friedel analyzer, degrees,

t_d = t_s = specimen thicknesses, 2.0 mm,

k = stress optical constant, 0.292 nm/cm/psi,

p = seal path length = 1.15 cm,

E = elastic modulus, 9.8×10^6 psi,

ΔT = setting point minus R.T., 900°C, and

F = shape factor.

The shape factor F which accounts for spacer shear and bending is given by:

$$F = \left[1 - \frac{4}{3}\left(\frac{t}{w-2b}\right)\left\{2\left(\frac{d}{b}\right)^3 + \frac{3}{2}(1+r)\left(\frac{d}{b}\right)\right\}\right]^{-1}$$

For this geometry, $F = 1.07$ (Poisson ratio $r = 0.17$)

Equation (1) reduces to:

$$\Delta\alpha = 1.63A$$

Our main interest is not in this $\Delta\alpha$ but in the $\Delta\alpha$ between 5 and 35°C. We have established for ULE™ that $\Delta\alpha$ is a constant for any two different specimens and applies over any temperature internal, providing thermal history is normalized. The question arises whether this holds for the downdraw vs. the standard specimens. Thus two of the sandwich seals were measured at 109°C as well as at 25°C to test this principle for the downdraw glass. Equation (1) is modified accordingly:

*A is replaced by ΔA, the change in analyzer rotation between 25 and 109°C

*$\Delta T = 84°C$

then $\Delta\alpha' = 17.5\ \Delta A$

5. Experimental Results

Resulting expansion differences are given in Table 1. All differences are in units of ppb/°C and are relative to the standard. Hence a negative sign signifies that the downdraw expansion is less positive than the standard.

The values for A in the table are in degrees and a letter C or T signifies that the downdraw specimen is in compression or tension, respectively.

For downdraw samples 50 and 53, the blue streaks made conventional reading of retardation impossible due to their opaque character. For these two sandwich seals the optical retardation was measured in the standards. To infer the reading in the central member, one must reverse the stress sense and multiply the retardation by a factor of two. The other seals verified this theoretical principle.

6. Conclusions

The grand average expansion of the remelt charge is -8 ppb/^{o}C. The standard material is experimentally defined as -6 ppb/^{o}C. Therefore, on the average, the expected $\Delta\alpha$ should be -2 ppb/^{o}C. Excluding sample 2, which seems to have a special problem, and samples 50 and 53, having blue streaks, the grand average $\Delta\alpha$ emerges as -4 ppb/^{o}C. Considering the variability of the standard (we used only 18 of the 39 pieces cut) and the uncertainty of the sandwich seal test, ±2 ppb/^{o}C, this is excellent agreement.

Sample 2 is a problem. Either the process has a start-up peculiarity or the bottom charge cylinder had a serious axial composition problem. Unfortunately no axial expansion data were taken on these charge cylinders. However we can get a chemical analysis on this piece (right from the sandwich seal) and at least answer the composition question.

For the special experimental setup that I used to determine $\Delta\alpha'$, the best ΔA uncertainty attainable is ±0.5^{o}C, which imparts an uncertainty in $\Delta\alpha'$ of ±9 ppb/^{o}C. Therefore, in consideration of these experimental uncertainties, $\Delta\alpha$ is statistically equivalent to $\Delta\alpha'$. Apparently then, the important principle of $\Delta\alpha$ being a constant has been preserved in remelting and drawing. <u>This is very encouraging!</u>

Blue streak material seems to impart a more positive expansion to the glass.

TABLE 1. Expansion Differences of Downdraw Specimens Relative to Standard

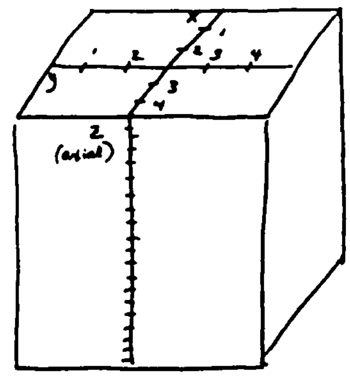
Sample ID	A	ΔA	$\Delta\alpha$	$\Delta\alpha'$
2	14C	-1.6	-23	-28
4	4C		-7	
8	4C		-7	
16	1C		-2	
24	0		0	
33	2C	-0.1	-3	-2
50	4T		+7	
53	6T		+10	

FIG. 1

RADIAL DOWNDRAW ABS. EXPANSION

PIECE NO 8 - Run 2 - STANDARD

RADIUS	AXIS X	AXIS Y	AVG
½	-8	-7	-6
1	-7	-8	
1½	-8	-7	
2	-7	-7	
2½	-6	-5	
3	-5	-3	
3½	-4	-2	
4	-1	-0	



Readings taken 5/10/84 by M. Best

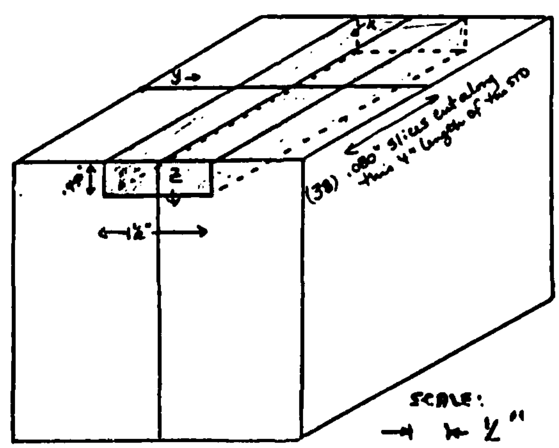
AXIAL DOWNDRAW ABS EXPANSION

PIECE NO 8 - Run 2 - STANDARD

note - only first ½" used for standard bread samples

DEPTH	ABS EXP	AVG
¼"	-3	-6
½	-5	
¾	-6	
1	-5	
1¼	-3	
1½	-3	
1¾	-2	
2	-1	
2¼	0	
2½	-3	
2¾	STRIEA	
3	-13	
3¼	-12	
3½	-11	
3¾	-10	
4	-10	

Readings taken 5/8/84 by M. Best

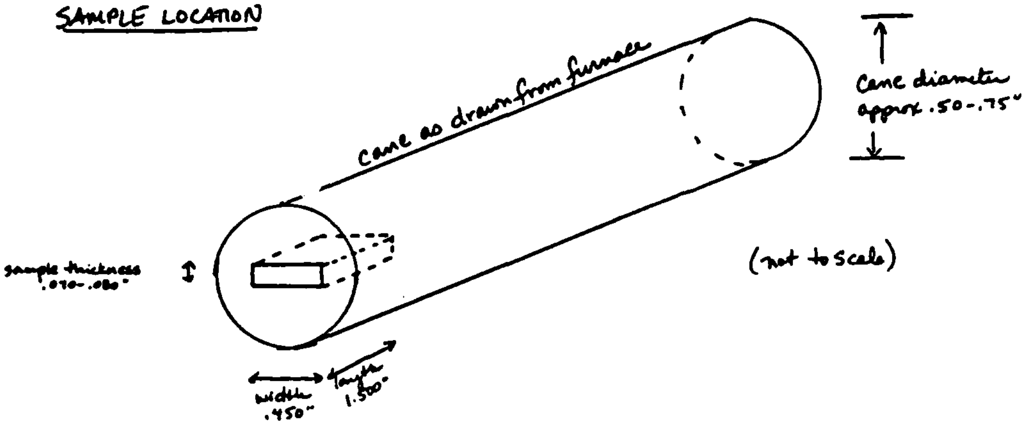


Piece #

FIG. 2

RUN 2 DOWNDRAW

SAMPLE LOCATION



Sample Identification	Time Taken in Run	Description of Cane
2	0800	Clear cane
4	--	"
8	--	"
16	0843	"
21 *	0854	"
24	0904	Surface devit?
33	0925	Clear Cane
50	0953	Several Blue Streaks
53	0956	Blue foamy center

* BROKEN UPON REMOVAL FROM FRIT FIRE FURNACE

FIG. 2A
RADIAL
DOWN DRAW GLASS ABS. EXPANSION
5/2/84
2nd RUN

Piece # 4 Thick. 4.42"

RADIUS	AXIS A	AXIS B	AXIS C	AVG	GRAND AVG
0	-9	—	—	-9	
1	-8	-10	-8	-9	
2	-7	-9	-8	-8	-8
3	-6	-9	-7	-7	
4	-4	-8	-9	-7	

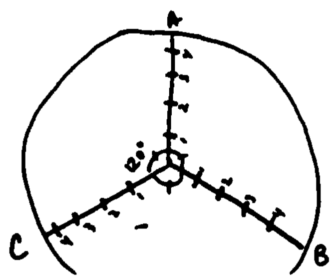
Piece # 5 Thick. 4.42"

RADIUS	AXIS A	AXIS B	AXIS C	AVG	GRAND AVG
0	-9	—	—	-9	
1	-8	-8	-9	-8	
2	-7	-9	-8	-9	-8
3	-7	-8	-9	-8	
4	-6	-7	-8	-7	

Piece # 6 Thick 4.42"

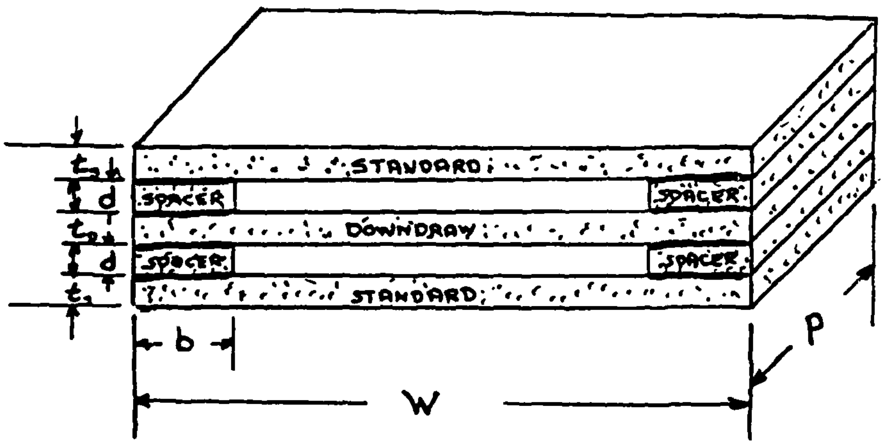
RADIUS	AXIS A	AXIS B	AXIS C	AVG	GRAND AVG
0	-9	—	—	-9	
1	-9	-9	-9	-9	
2	-9	-9	-9	-9	-9
3	-8	-9	-8	-8	
4	-7	-9	-9	-8	

TOP VIEW



NOTE: These are the readings from the three 9½" diameter disks placed in the furnace for run 2. Each disk weighed 25 lb.

FIG. 3 SPACED SANDWICH SEAL GEOMETRY



W = 37.7 mm

d = 2.2 mm

$t_o = t_s =$ 2.0 mm

b = 6.6 mm

p = 11.5 mm.

NOTE: HEAVY LINES REPRESENT FRIT JOINTS

To: Ms. Deborah Foss - Canton

cc: Mr. E. T. Decker
Dr. A. M. Filbert
Mr. E. H. Fontana
Mr. H. G. Freeland
Mr. W. C. Lewis
Mr. C. E. Peters
Mr. C. L. Rathmann
Mr. K. J. Schmidt
Mr. P. M. Smith
Mr. N. D. VanDyke

From: H. E. Hagy Date: August 3, 1984

Subj: Downdraw Sample 2

As suggested in my conclusions in the subject report of July 26, chemical analyses were made on both standard and sample 2. The report is attached.

The difference is wholly explained by TiO_2 differences as one can see from my scribbling. Thus, it seems logical to exonerate the process.

/jt
Attachment

(REPORT SHEET)
NALYTICAL SERVICES RESEARCH DEPARTMENTAL ANALYSIS REPORT

ITTER: [redacted]
GE NO: 949203450474008
07/31/84
ONHOLE: 21

SAMPLE: CODE 7971 OR 918A
SAMPLE # 5348- 5349/84
PROJECT NAME: ULE DOWNDRAW
SPECTRO
PLATE NO- GQ-84-103

LE DESCRIPTION

-84= CODE 7971; SEAL TEST STANDARD
-84= SAME PHASE I; RUN 2; DOWNDRAW SAMPLE NO. 2

OSE

PECTED EXPANSION DIFFERENCE DURING REMELTING & DOWNDRAWING
INS FOR CHEMICAL COMPOSITION TO EXPLAIN EXPANSION DIFFERENCE
EEN STANDARD AND DOWNDRAW

GNED TO	ANALYSIS DESIRED	ANALYST NO	DATE REPORTED
	SPEC	ANP-1148	7/31/84
	TI	CSW-195	7/30/84

TE REPORTED 8/1/84 jm REPORT SENT TO: RAB, JSS

CARD NO.	$\%TiO_2$	
5348	6.99	[std] (this would be ~~higher~~ more positive expansion - agrees with seal test)
5349	7.31	[downdraw]

Spec attached

$$\frac{(7.31 - 6.99)}{7.4} \times 0.5 = 0.022 \text{ ppm}/°C$$

$$= 22 \text{ ppb}/°C.$$

magnitude agrees!

REPORT SHEET

SPECTROGRAPHIC SEMI-QUANTITATIVE ANALYSIS

Spectro Plate No. GQ-84-103 Analysis Spec

Analyst No. ANP-1148 Date 7/31/84

Procedure & Comments:

	Std	Sample		
#	5348-84	5349-84		
%	Si	Si		
-30%				
-10%	Ti	Ti		
-3.0%				
-1.0%				
-0.3%				
-0.1%				
-0.03%				
01%	Al	Al		

Typical lower determination limits for all the elements examined are:

)%	-
3%	K,P
.%	As,Cd
)3%	Nb,Zn
)1%	Ag,Al,B,Ba,Be,Bi,Ca,Co,Cr,Cu,Fe,Ga,Ge,In,Mg,Mn,Mo,Na,Ni,Pb,
	Sb,Si,Sn,Sr,Ti,V,Zr

AD-A153 783 DOWNDRAW EXTRUSION OF ULE(TM) GLASS(U) CORNING GLASS WORKS CANTON NY P M SMITH ET AL. DEC 84 RADC-TR-84-259 F30602-83-C-0121 2/2

UNCLASSIFIED F/G 11/2 NL

END
FILMED
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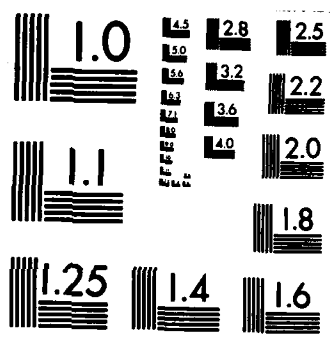

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

MISSION
of
Rome Air Development Center

RADC plans and executes research, development, test and selected acquisition programs in support of Command, Control Communications and Intelligence (C^3I) activities. Technical and engineering support within areas of technical competence is provided to ESD Program Offices (POs) and other ESD elements. The principal technical mission areas are communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data collection and handling, information system technology, ionospheric propagation, solid state sciences, microwave physics and electronic reliability, maintainability and compatibility.

END

FILMED

7-85

DTIC