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A Prototype Backside Purge Control System

Final Report

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Marshall Space Flight Center, Alabama 35812

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1.0 Introduction

Due to difficulties experienced by NASA in achieving adequate backside purge conditions on large scale weldments a program was initiated at Nichols Research Corporation (NRC) to develop a prototype backside purge control system. During this development effort the backside purge process was analyzed, a control/data acquisition system was developed and assembled, a control strategy was developed for large chambers, and purge chamber data was taken on a variety of welding applications. The results of these activities are summarized below.

2.0 Review of Past Work

In an attempt to better understand the backside purge process, meetings were held with various NASA, Martin Marietta, and Babcock & Wilcox (B&W) personnel. A significant amount of work has been and is currently being conducted by these investigators and a great deal of insight was gained. NASA and Martin Marietta are working on purge chamber designs and purge techniques for aluminum-lithium (Al-Li) alloys and B&W is is in the process of developing a purge control system for welding HP9-4-30 material. The insight into the backside purge process provided by these investigators is included in the process analysis that follows.

3.0 Process Analysis

New lightweight aluminum-lithium alloys are being considered for propellant tank and aerospace structural applications. These alloys can be successfully welded using the Variable Polarity Plasma Arc Welding (VPPAW) process provided the weldment is protected from the effects of atmospheric oxygen contamination until it cools below a temperature of about 300 degrees Fahrenheit. This protection is typically accomplished by flooding both the front and back sides of the weldment with an inert gas such as argon, helium, or a mixture of the two. The inert gas displaces atmospheric oxygen until the desired temperature is reached. This gas must be maintained at a pressure and flow rate that does not significantly effect the stability of the weld pool or plasma jet. Excessive pressures can physically affect the molten weld pool significantly while pressures equal to or below atmospheric can allow oxygen to enter the chamber. Control of this process on the back side of VPPA welds has proven to be difficult in large volume chambers.

Discussions with various investigators revealed a difference of opinion concerning the maximum allowable Oxygen content and chamber pressure for the welding of Al-Li. However, a maximum Oxygen content of 2% and a maximum chamber pressure of 0.3 inches of water seem to be conservative limits. The HP9-4-30 material has less stringent backside purge requirements, with pressure being the primary purge parameter for this material. The conservative maximum purge pressure seems to be 1.5 inches of H_2O. Acceptable oxygen concentrations are much greater for HP9-4-30 although a specific limit was not discussed. B&W is in the process of implementing a backside purge control system for ASRM welding that controls chamber pressure by adjusting input gas flow, which assumes adequate pressures will insure acceptable Oxygen concentrations.

Past Al-Li welding experience has shown that for small (two feet long) vertical chambers maintaining the desired purge conditions is a relatively simple matter of maintaining a limited but adequate flow of purge gas through the chamber. Very little variation in chamber conditions occur during these short welds.

When these same techniques were applied to large (fifteen feet long) chambers at MSFC the results were drastically different. Oxygen content varied dramatically from one end of the chamber to the other. The reasons, although not completely understood, appear to be variable leak rates, segregation of the purge gas and atmosphere (He rises and Ar falls), and the effects of greater temperature variations than existed in the small chambers. It has been shown that feeding He in at the bottom of a large chamber and allowing it to exit at the top, as was done in the small chambers, results in much greater concentrations of He at the top vs. the bottom of the chamber. This results in insufficient purge at the lower sections of the chamber. This has been termed by some as the "chimney effect". Opposite, but similar, results were observed with argon.

The next step in development was to develop a small chamber capable of being moved along with the torch. The idea here was to keep the small chamber that had worked previously, and make it mobile to allow longer welds to be made. After several refinements to this method good results were achieved and this approach appears to be a viable solution for tools where the torch moves, the weldment is stationary, and sufficient space is available to mount the movable chamber and its motion mechanism. This approach also has potential for tools where the torch is stationary and the weldment moves if innovative methods for chamber mounting (space permitting) can be developed.

Other non-traditional purge techniques are being considered at this time, but it is too early to predict their feasibility for application.

For obvious economic reasons, existing fixtures and tooling will have to be used if the Space Shuttle External Tank (SSET) is to be fabricated using Al-Li alloys. Many existing tools do not have adequate space or access to accommodate the moving/sliding purge chamber solution described above.

The goal of this effort is to instrument, monitor, and control conventional large scale purge chambers in an attempt to provide adequate backside purge conditions. The specific objective of this project is to build a control system capable of controlling the backside process for a large (10 foot dia.) chamber.

4.0 Controller Specification

The general approach used was to provide the capability of accurately sensing chamber Oxygen concentration and pressure at multiple locations around the chamber and providing the capability of controlling input gas flow rate and input location. Based on the backside purge process characteristics described in section 3.0 a set of controller hardware was specified and assembled, as shown in Figure 1.

The control system includes a computer and a control box containing the sensors and I/O. An IBM PC compatible (486) was chosen as the controller computer for ease of programing and easy access to off-the-shelf I/O. Sixteen channels of analog I/O and thirty two channels of digital I/O were added for controlling gas input flow and location, and monitoring sensor outputs. Nine differential pressure sensors (0 to 4 inches of water column) and one Oxygen sensor (0-25 % oxygen) are included in the system. This will allow monitoring of the chamber pressure at nine locations simultaneously. Due to the relatively high cost of the Oxygen sensor, a single sensor will be connected to a maximum of nine Oxygen sensing ports via a nine valve manifold. Only one position on the purge chamber can be selected/monitored for Oxygen content at a given time. Considering the typical welding speeds this should be adequate for both process evaluation and real time control. This system has the capability of logging purge chamber data to disk as often as two times a second.

5.0 Candidate Selection

Based on all of the information gathered in the process analysis phase of this project, some process control concepts have been developed. It should be noted that these concepts are primarily aimed at controlling the backside purge process for the new NASA ten foot diameter chamber which was previously selected for demonstrating the control system developed under this project. However, all of the concepts described below have potential application on a variety of tooling configurations and orientations. It is believed that using this chamber design properly instrumented along with the control concepts developed under this project will provide an adequate purge on the backside of an Al-Li weldment. The chamber design, instrumentation, and control concepts aredescribed in the following sections.

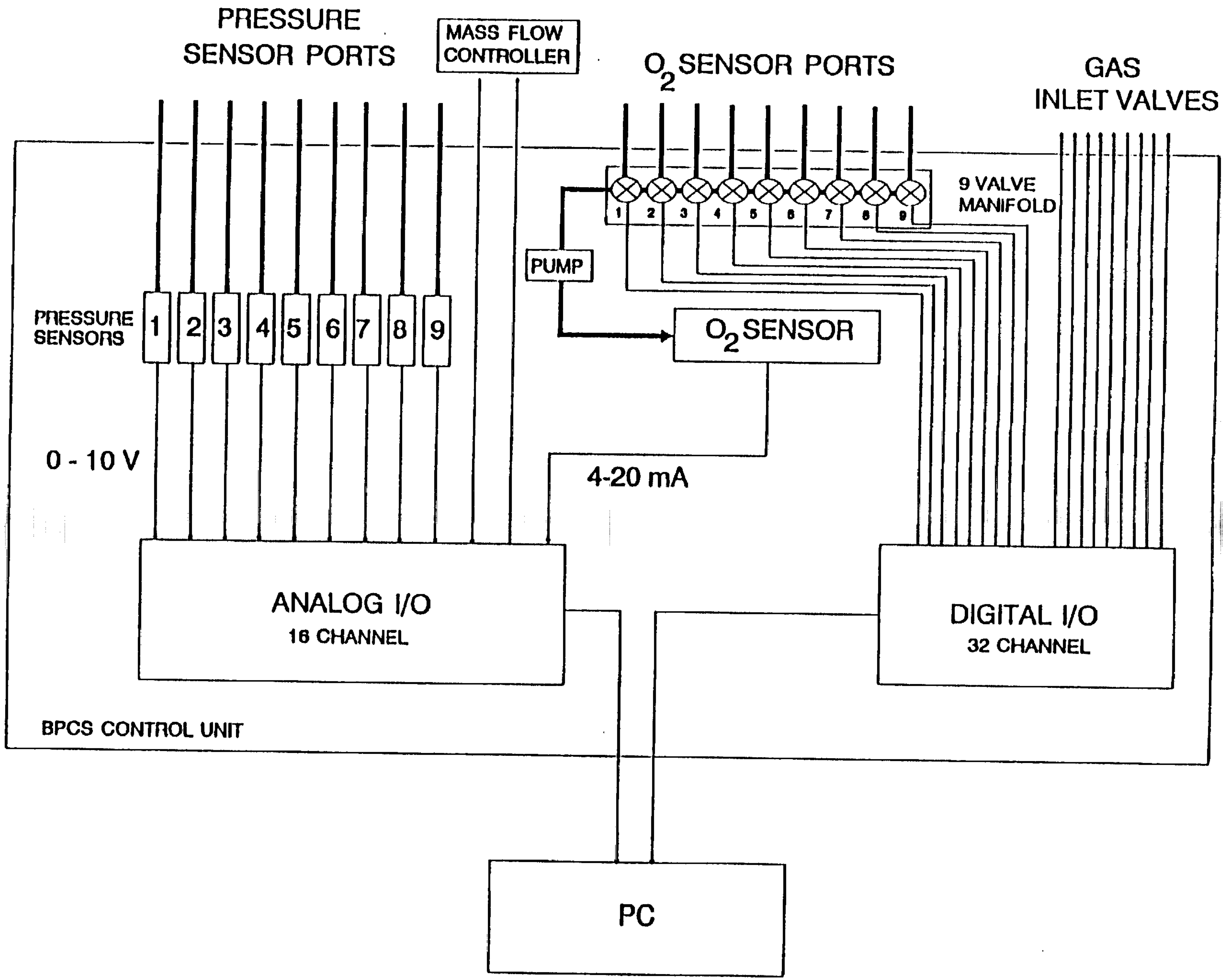


Figure 1. Backside Purge Control System Controller Block Diagram

5.1 Chamber Design

The new NASA 10 foot diameter tool and purge chamber is intended to simulate the 5019 production mandrel, which incorporates a fixed torch and moving cylindrical weldment. The purge chamber (Figure 2) on this tool incorporates 36 ports on the side of the chamber. Each of these ports will be used as a purge gas inlet. Purge chamber leakage should be substantial enough to act as the purge gas outlet. If additional outlets are required, they can be added easily. As shown in Figure 3, purge gas flow will be regulated from the source with a mass flow controller and valved at nine locations around the chamber. The nine solenoid valves will allow the input flow to be independently regulated at each section of the chamber. The mass flow controller can be adjusted appropriately for the number of valves open at any point in time.

The main problems with large volume purge chambers is attaing even distribution of purge gas throughout the chamber. Helium concentrates at the top of the chamber and argon concentrates at the bottom. Multiple gas inlets, as designed into this chamber, should lessen this effect, however it may still exist in open chambers.

An additional means of limiting purge gas migration has been developed. Placing baffles inside the purge chamber to impede gas movement, in theory, would divide the chamber into small individual compartments although some leakage around the baffles will be inevitable.

The typical application of welding aluminum cylinders in the vertical up position could benefit greatly from a baffled chamber. With the torch at the 9:00 position and using helium purge gas, the maximum concentration of purge gas (i.e. min. Oxygen content) will be at the 12:00 position with a potentially less than optimum purge gas concentration at the torch position. A closed baffle slightly above the torch position would provide a higher purge gas concentration at the weld.

The main problem with baffles in a purge chamber is that they must move away from the weldment before the arc reaches their location to avoid melting the baffle and possible contamination of the weld. A preliminary design has been developed that would use gravity to actuate the baffles. Figure 4 illustrates this baffle concept. The baffle is hinged with a counter weight attached to the section nearest the weldment. The position in the tool/chamber rotation at which the baffle opens is determined by the location of the weight with respect to the baffle pivot point. In general, the baffle should open sufficiently that it is not damaged by the arc at point just above the welding position. The optimum baffle geometry and positioning should be determined experimentally. The efficiency of baffles for slowing purge gas movement and their mechanical reliability will greatly affect their usefulness for this application, and therefore should be thoroughly evaluated.

5.2 Chamber Instrumentation

By instrumenting the chamber as shown in Figure 5, a great amount of knowledge about purge gas distribution, contamination and pressure can be gained. This concept includes nine oxygen sensing ports and nine pressure sensing ports located at 40° increments around the chamber. Sensing oxygen concentration and chamber pressure at these locations should be sufficient to investigate the backside purge process and then implement real time control. As previously noted in Section 4, nine pressures can be monitored simultaneously while only one oxygen sensor is available. The port nearest the torch will be monitored for oxygen concentration.

5.3 Control Concepts

The key to the control concept developed is the use of a flow controller and the ability to input gas at multiple positions (9 at 40° increments) around the chamber. By monitoring the oxygen concentration and pressure near the torch, input gas flow and location can be regulated in an attempt to maintain an acceptable purge. It is proposed that areas away from the torch may not need input gas. Oxygen concentration would be the primary observable and input flow would be regulated to maintain a oxygen concentration level below a specified maximum. The pressure nearest the torch would be used as a limit on flow so that maximum pressure levels are not exceeded. To summarize, input location would be scheduled, input flow would be regulated with respect to oxygen concentration and limited by pressure. If acceptable oxygen concentrations can not be obtained at the torch location without exceeding the pressure limit, baffles should be incorporated to limit gas migration.

It should be noted that tool delivery delays and schedule conflicts at NASA, beyond NRC's control, prevented the evaluation and demonstration of these control concepts.

6.0 System Evaluation and Data Acquisition

With no tool available for implementing purge control it was decided to use the control system to take purge chamber data during welding on a variety of welding tools. After gaining confidence that the oxygen and pressure sensors were providing accurate and repeatable information the data acquisition activities began. These sensor evaluations and purge process data investigations are detailed in the following sections.

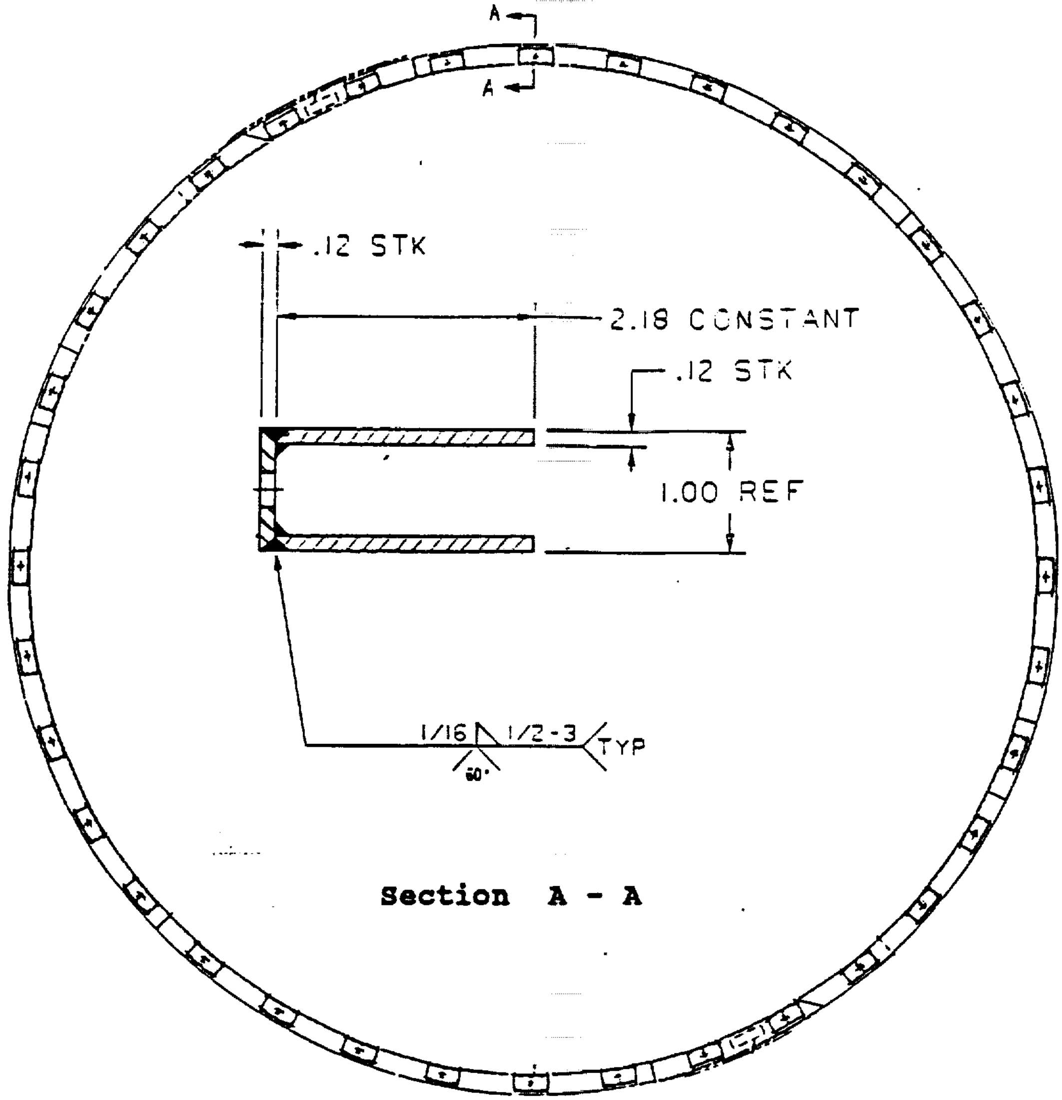


Figure 2. Ten foot diameter purge chamber design

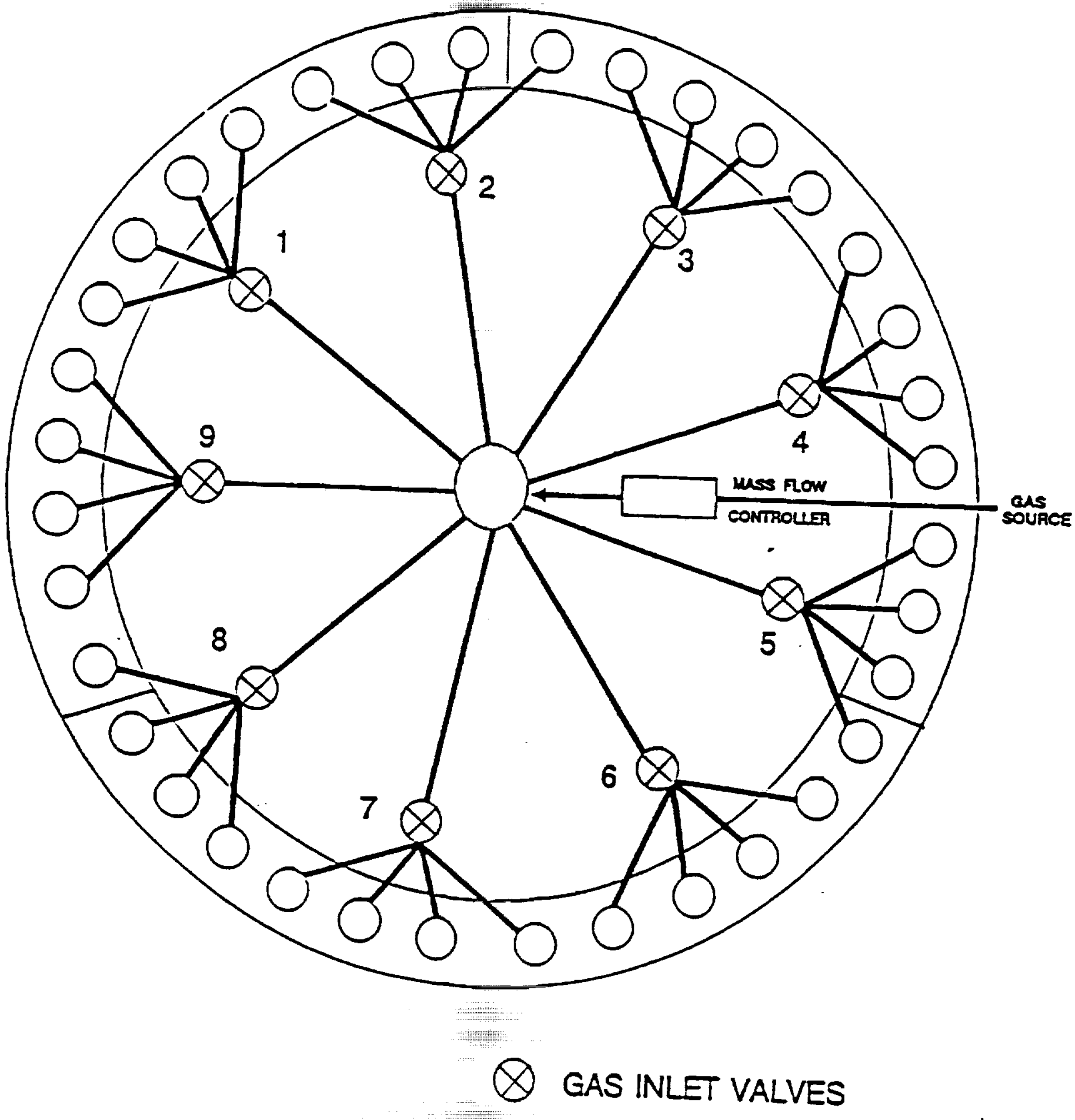
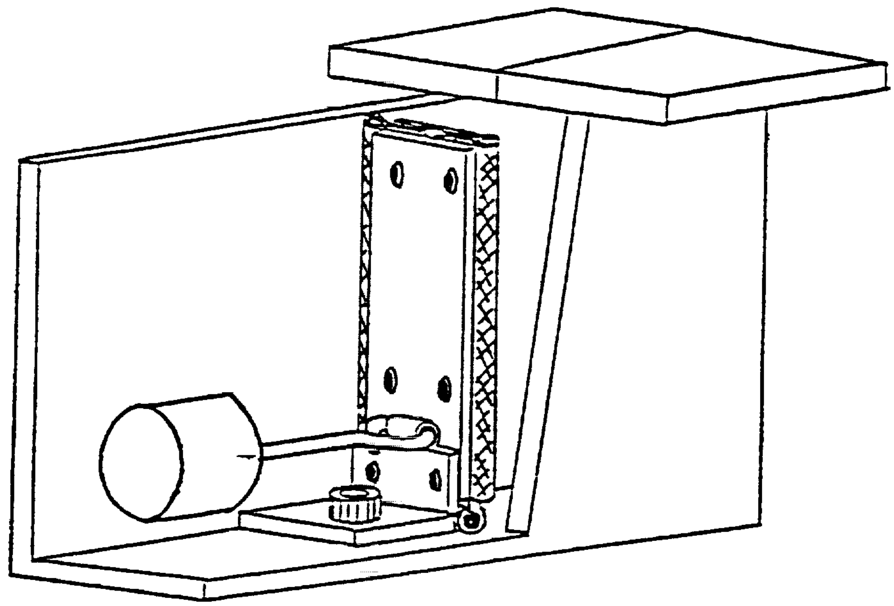
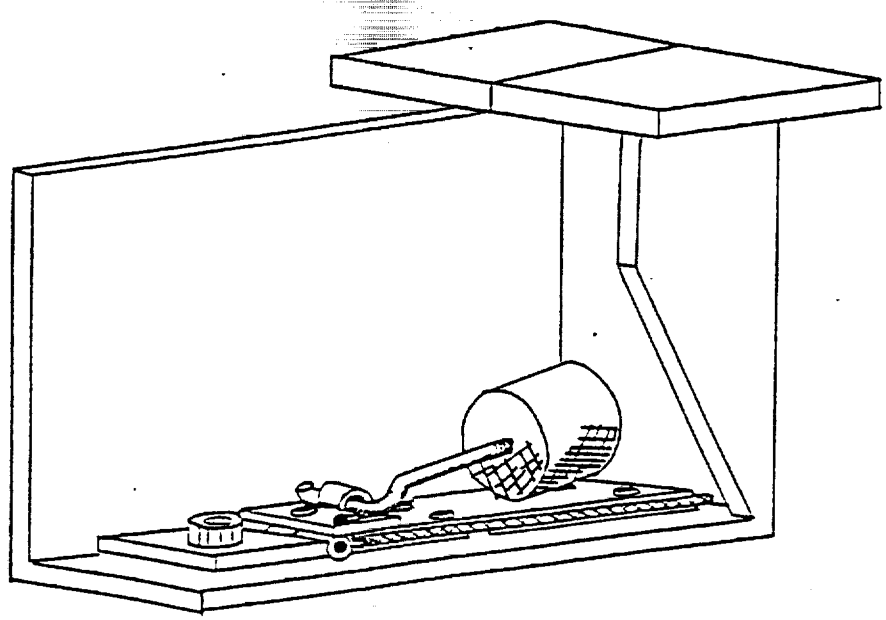


Figure 3. Ten foot diameter purge chamber gas input concept



CLOSED



OPEN

Figure 4. Self actuating baffle design

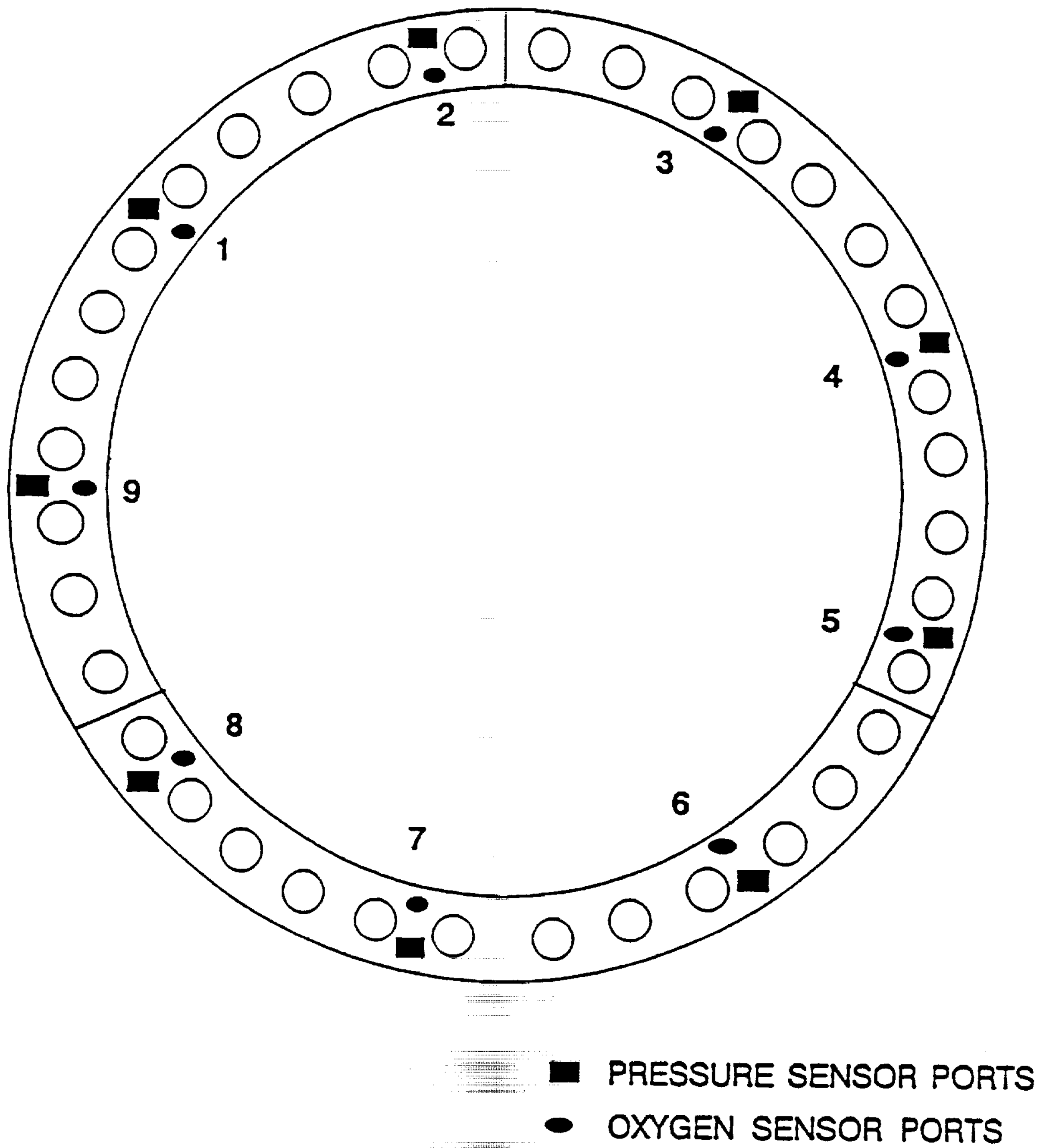


Figure 5. Purge chamber sensor port locations

6.1 Sensor Evaluations

Before taking data a few tests were conducted to gain confidence in the oxygen and pressure sensor outputs. The oxygen sensor was calibrated for the range of interest for this project, which was the area around 2% Oxygen concentration. Pressure sensor repeatability between the nine sensors was also determined.

The pressure sensor was calibrated at the factory before shipment with a vendor quoted accuracy of + or - 1% F.S./ + or - .04 in. H_2O. As stated previously nine of these differential pressure sensors are used in the subject backside purge control system. The main concern was the repeatability between the nine sensors. Per the vendor, the largest component of inaccuracy for these sensors is the zero offset. To eliminate this error each of the nine sensors was zeroed prior to each use. It should be noted that after the initial zeroing very little change in the zero output was experienced. To compare the output of the nine sensors an experiment was conducted to expose each sensor to the same pressure and simultaneously record their response. This was done by connecting a pressure source to a nine way manifold with each of the nine manifold outlets connected to one of the pressure sensors. The pressure was then cycled in the appropriate range for these sensors while the output of each sensor was recorded. Figure 6 shows the output of six of the sensors over a 400 second time frame. Only six outputs could be displayed on a single plot due to the limits of the graphics utility used. The response of the other three sensors was identical to those show in Figure 6. Based on these results the sensor to sensor variation is insignificant.

The oxygen sensor was also calibrated at the factory with a vendor quoted accuracy of + or - .1% Oxygen concentration. The typical use of this sensor is monitoring atmospheric oxygen concentrations in order to determine if sufficient oxygen is present for human respiration. The oxygen concentrations of interested interest ot this project (~2% Oxygen) were much lower than the normal atmospheric concentrations (~20% Oxygen). For this reason it was necessary to recalibrate the sensor for the 2% range. This was done by adjusting the offset and verified using a calibration gas. The gas used was certified as being 2.21% Oxygen with the balance being helium. Figure 7 shows the sensor output as recorded by the controller when the sensor was exposed to the calibration gas and then vented back to atmosphere. Notice the overshoot experienced both when the sensor was exposed to the calibration gas and again when it was vented to atmosphere. This response suggests that a minimum warmup time of three minutes is required for the sensor to stabilize. Considering the typical purge cycle this should not be a problem for backside purge process control. This test was repeated numerous times with the same results.

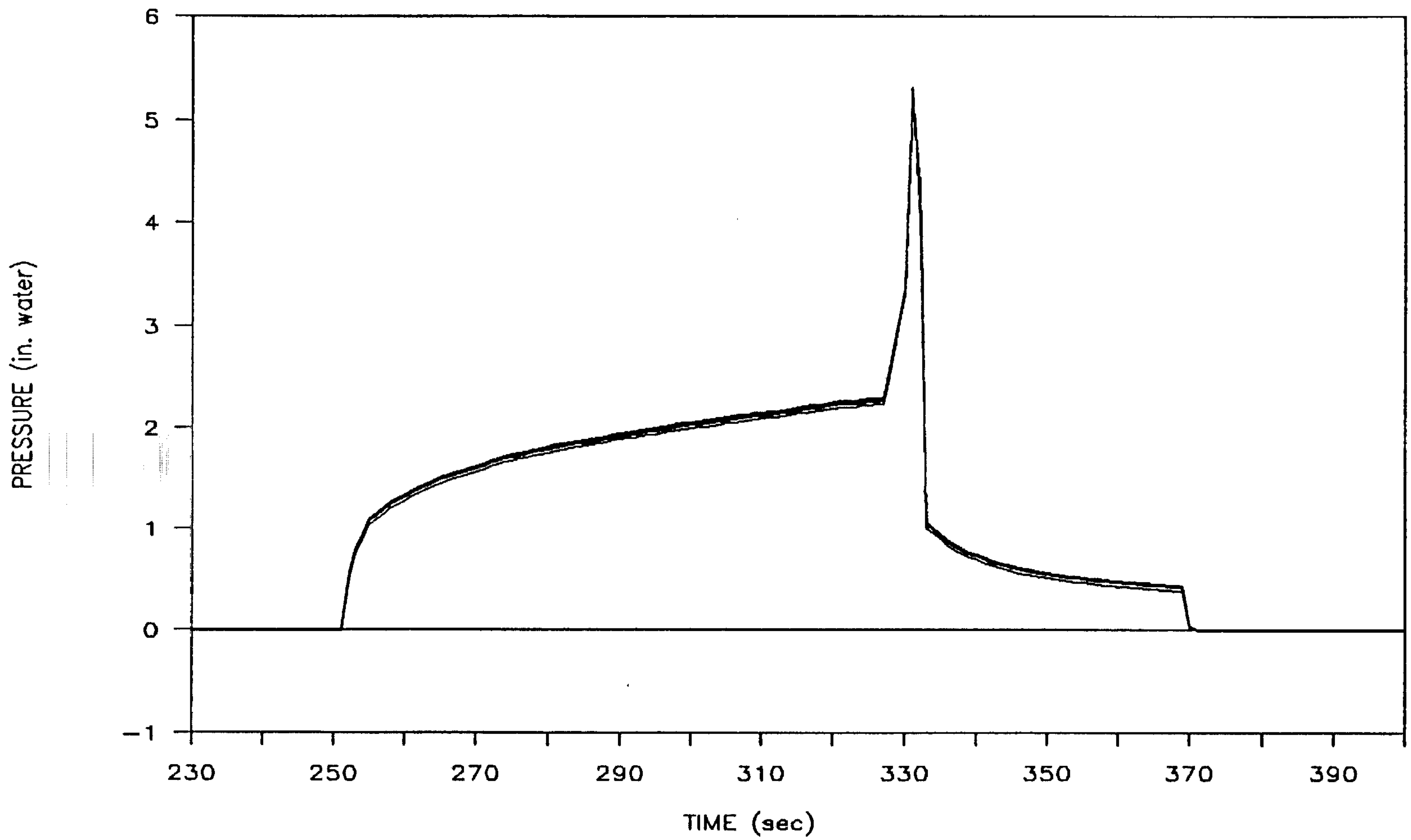
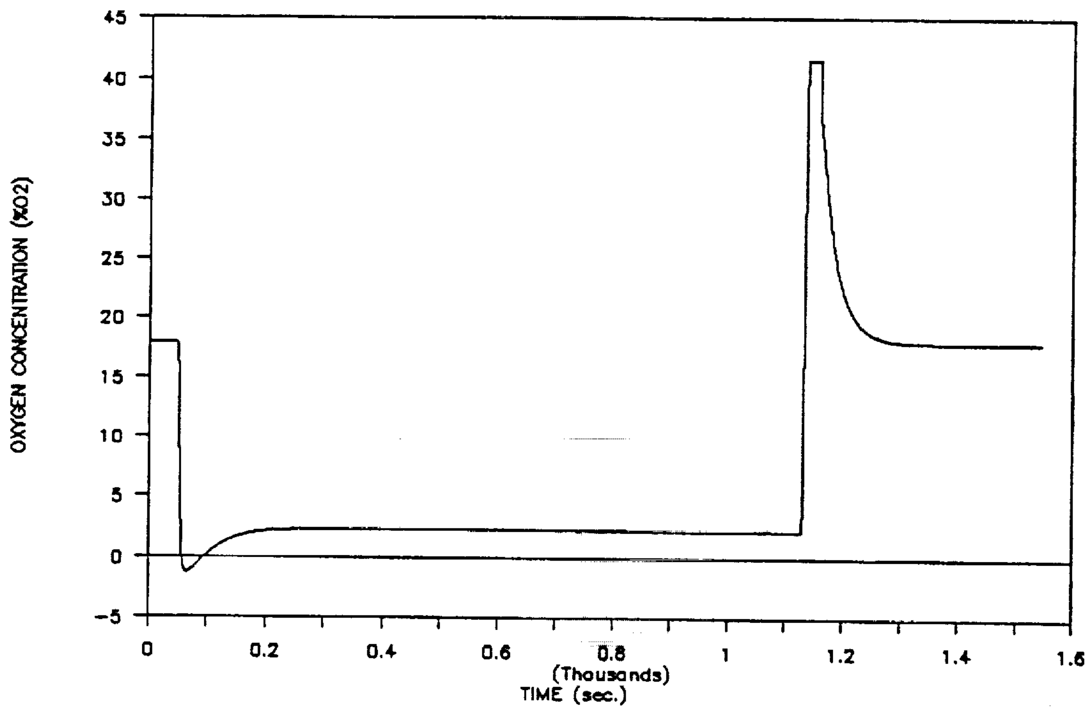


Figure 6. Comparison of pressure sensor outputs



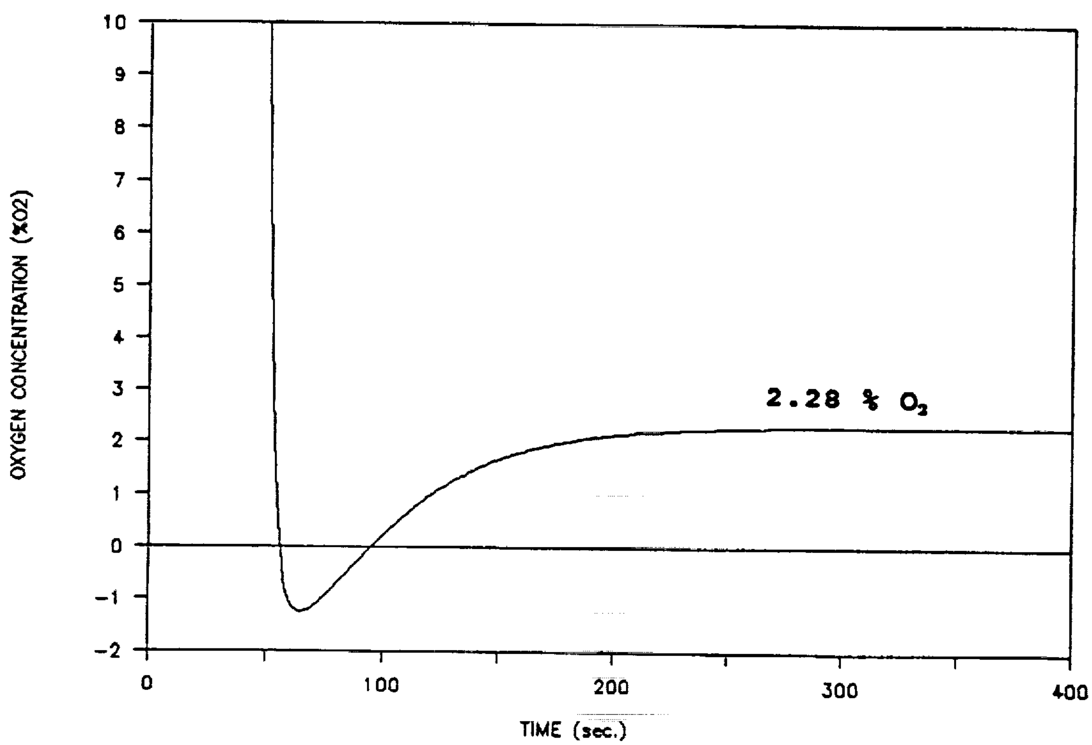


Figure 7. Oxygen sensor calibration data

6.2 Purge Process Data Investigations

Backside purge conditions during welding were monitored for a variety of welding applications. This exercise was intended to evaluate the sensing and data acquisition capabilities of the backside purge controller as well as to investigate the backside purge process behavior of various welding applications. Data was taken during the welding of 2219-T87 aluminum, 2095 Al-Li, and HP9-4-30. High purity helium purge gas was used for all tests.

Figure 8 shows the purge pressure and oxygen content for a vertical-up keyhole weld on 0.250" 2219-T87 aluminum which was conducted on weld station #1 in building 4711, MSFC. The purge chamber at this station is typical of the two foot test fixture used by the Metals Processes Branch, MSFC. The purge gas is introduced at both the top and bottom of the chamber and an open gas outlet is provided at the bottom of the chamber. The controller logged sensor data at 1 Hz for this weld. The oxygen concentration is shown on the lower line which shows an oxygen content of less than 0.1% was maintained. The oxygen concentration slowly decreased throughout the weld as the chamber became more saturated with helium. The top line displays chamber pressure. The time at which the arc is started and stopped is obvious on the pressure plot. When the arc is established pressure increases rapidly and then fluctuates slightly around a higher level than the preweld pressure. Distinct pressure spikes can be seen at the beginning and end of the weld. The increase in pressure is thought to be caused by the addition of torch gasses (plasma and shield gas) through the keyhole. These gasses along with the arc cause the pressure fluctuations. This pressure plot was typical of all those recorded while keyhole welding with small purge chambers.

A 2095 Al-Li weld was also conducted on weld station #1. Figure 9 shows very similar data as that obtained on the 2219 weld. The main difference is the slightly lower pressure and slightly higher oxygen concentrations observed. A lower input gas flow rate and/or a higher leak rate would account for this behavior. Either would theoretically result in a lower purge pressure and a resulting increase in oxygen concentration.

The remaining tests were conducted on HP9-4-30 material. Figures 10 and 11 show pressure data obtained from sub-scale ASRM ring welds made on the ASRM test fixture in building 4705, MSFC. The samples were welded one half at a time to evaluate root pass flying starts and stops as well as "tie-ins". Tie-ins refers to the start or termination of a weld on a previous weld. These welds were part of a Metals Processes Branch procedure development task and the use of an oxygen sensor was not allowed because it would have possibly restricted purge gas throughput. Figure 10 represents the first half weld made and Figure 11 the second. These plots follow the typical pressure response seen in

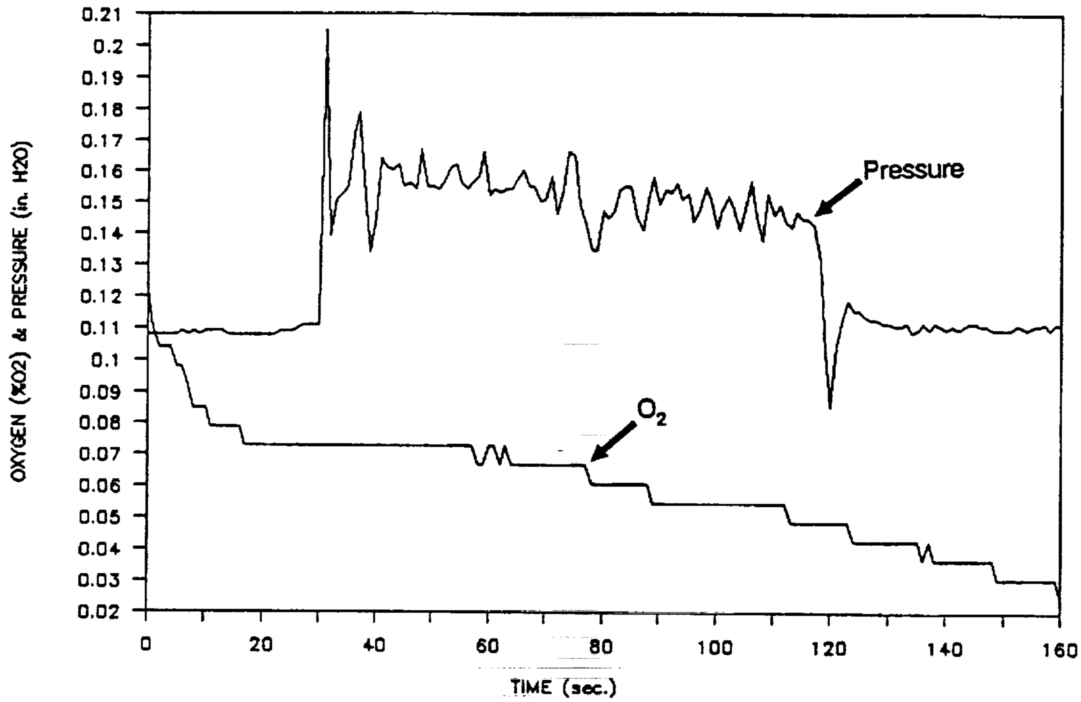


Figure 8. Purge chamber oxygen concentration and pressure for vertical up keyhole weld in .250 in. 2219-T87 aluminum

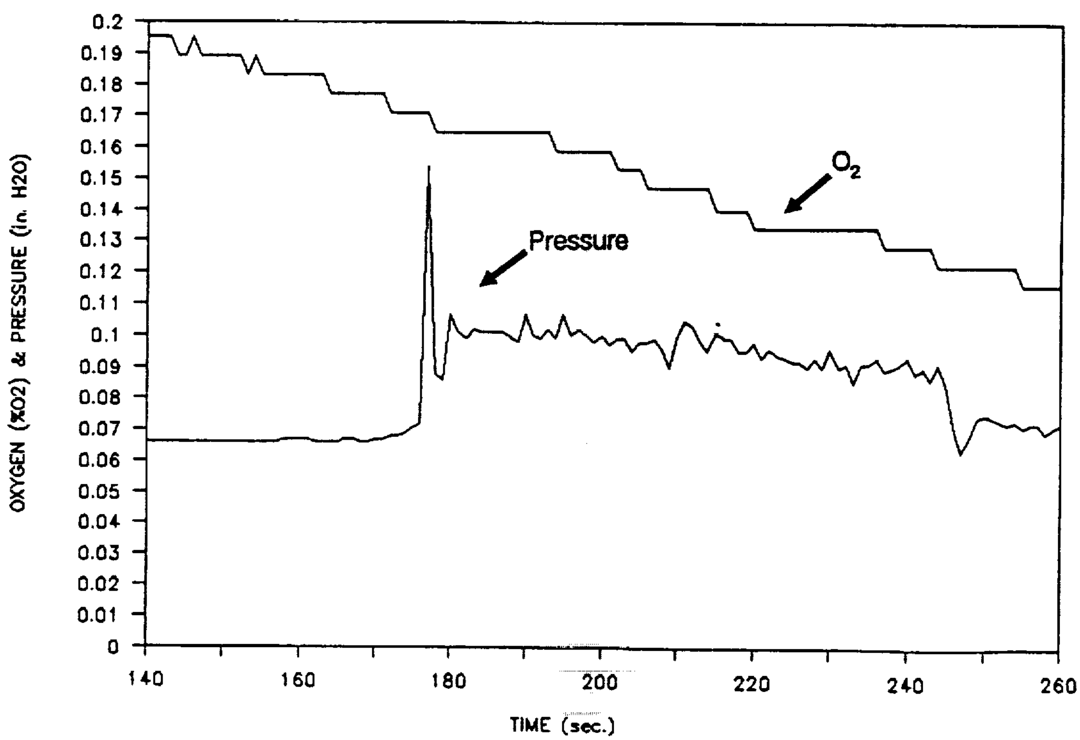


Figure 9. Purge chamber oxygen concentration and pressure for vertical up keyhole weld in .250 in. 2095 Al-Li alloy

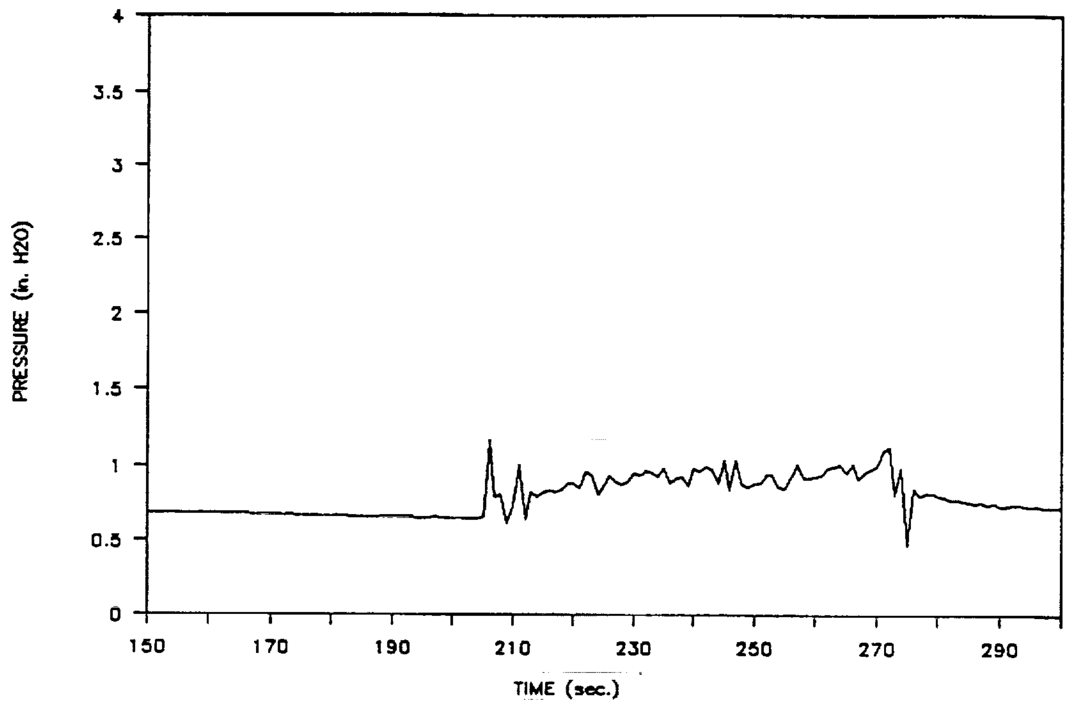


Figure 10. Purge chamber pressure for "down hand" flying start keyhole weld in HP9-4-30 on ASRM test fixture (first half)

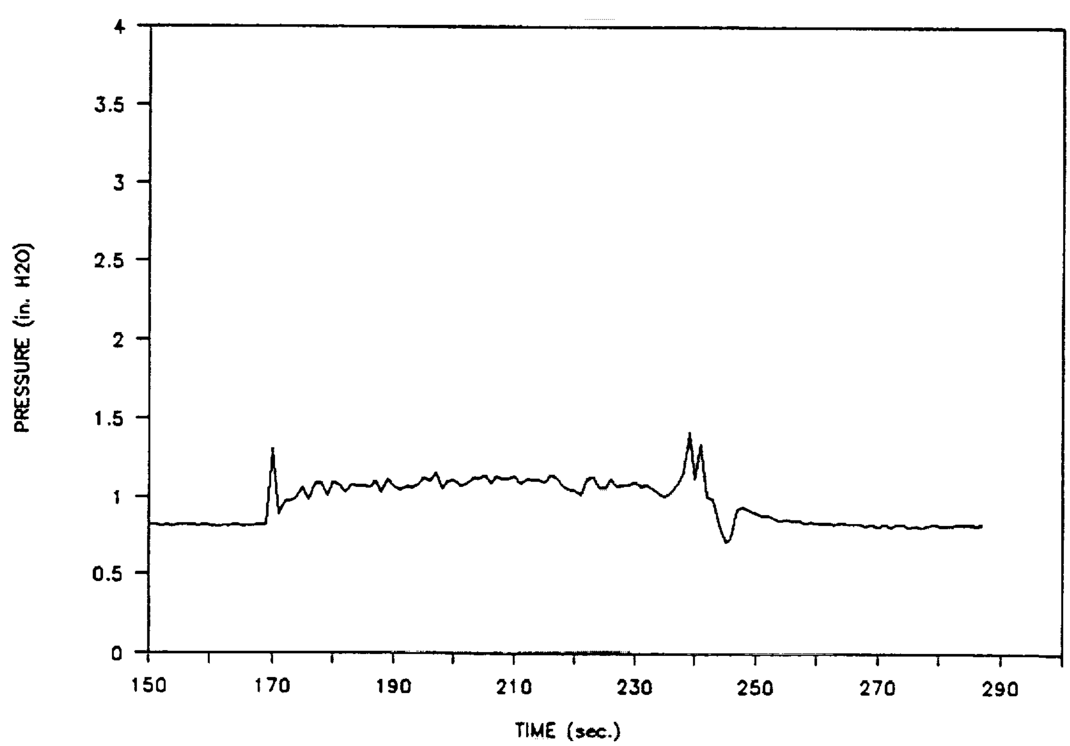


Figure 11. Purge chamber pressure for "down hand" flying start keyhole weld in HP9-4-30 on ASRM test fixture (second half)

the 2219 and 2095 welds. The only difference is the higher nominal pressure used in welding the HP9-4-30 material.

The plots shown in Figures 12 and 13 are nontypical. These welds ,also conducted on the ASRM test fixture, are companion half welds like those shown in Figures 10 and 11. The pressure in Figure 12 starts out normal, then a short way into the weld it increases dramatically and maintains a high level even after the arc is extinguished. Figure 13 shows that pressure increases significantly just prior to the start of welding, then steadily decreases to the level that would have been expected about half way through the weld. The unusual event in this welding sequence was that a tack weld broke shortly after the first half weld was started. It is believed that this resulted in a significantly larger root opening which allowed more torch gasses into the purge chamber. This additional gas load increased the pressure in the chamber. The post weld shield gas purge maintained this high pressure even after the arc was extinguished. The rise in pressure just prior to the start of the second half weld (Figure 13) is due to the preweld shield gas purge. As welding progressed the root gap was closed and pressure decreased to a typical level. Oxygen content was also plotted during these welds and shows some interesting behavior. At the initiation and closure of the keyhole slight momentary increases in oxygen content are observed.

The remaining plots shown in Figures 14 to 18 represent the pressures recorded by the four sensors used during the root pass weld of the 10 foot diameter ASRM ring. Four pressure sensor ports were installed in the purge chamber 90° apart. The main points of interest in these plots is that the pressure remained relatively constant during welding and all significant pressure variations in the chamber were transmitted to each sensor. The sudden pressure increase observed by all sensors about 1/3 into the weld (~1800 sec.) was due to an adjustment made at the purge gas bottles.

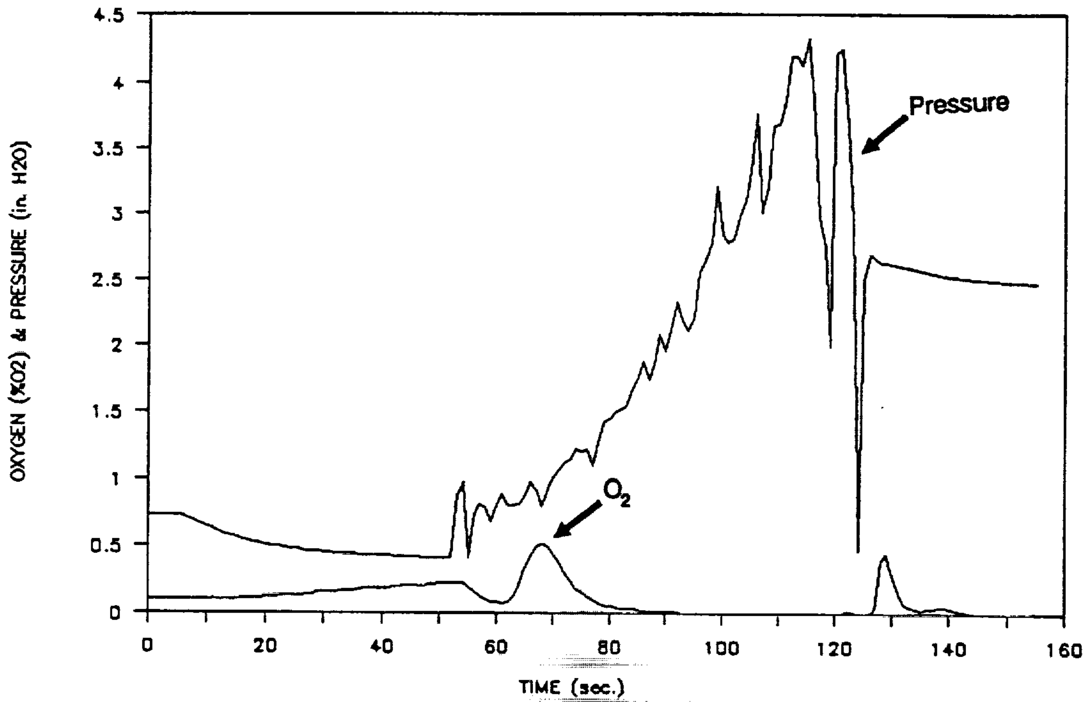


Figure 12. Purge chamber pressure for "down hand" flying start keyhole weld in HP9-4-30 on ASRM test fixture (first half)

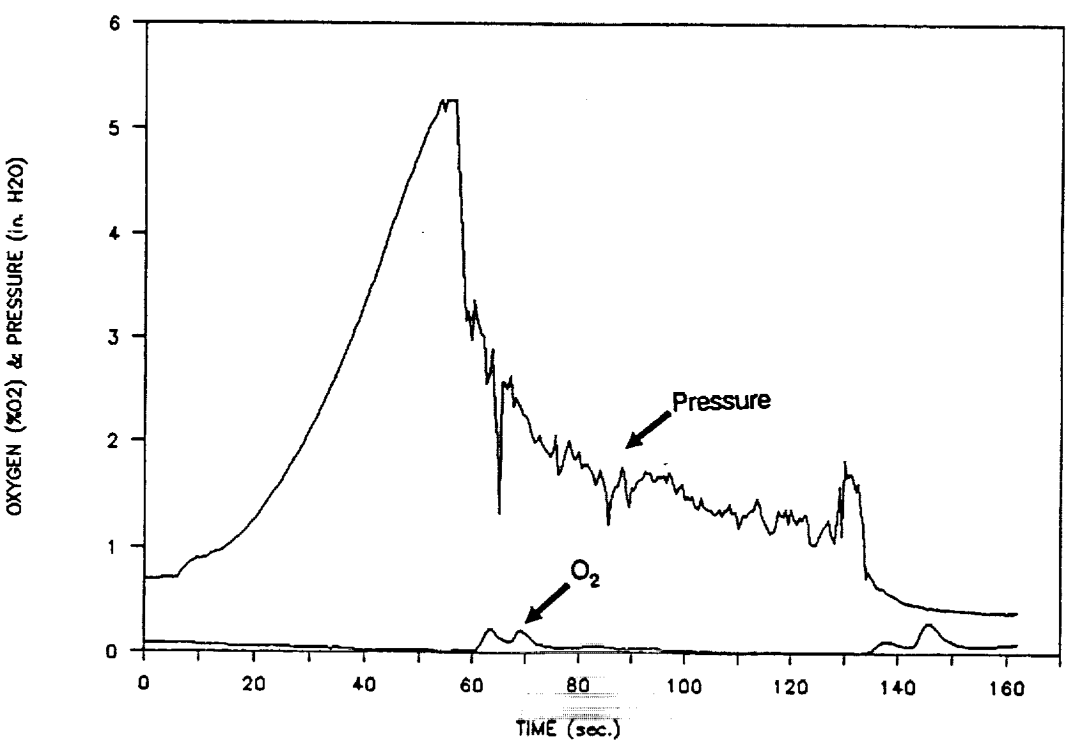


Figure 13. Purge chamber pressure for "down hand" flying start keyhole weld in HP9-4-30 on ASRM test fixture (second half)

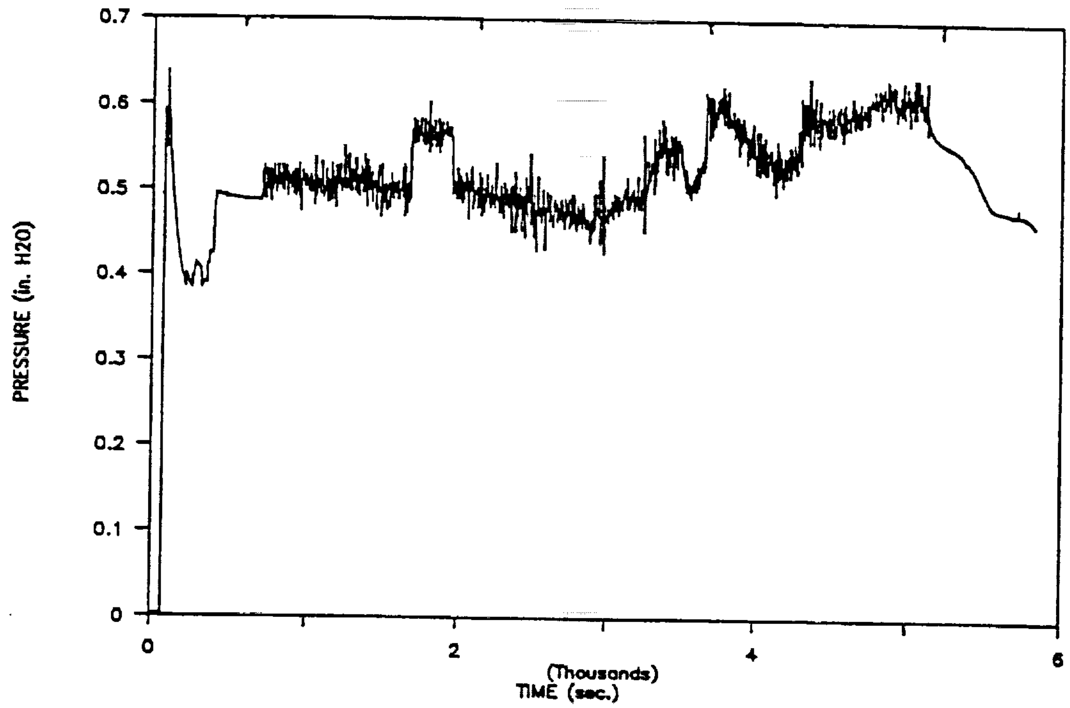


Figure 14. Purge chamber pressure at pressure sensor #1 during keyhole weld of HP9-4-30 on ten foot dia. ASRM ring

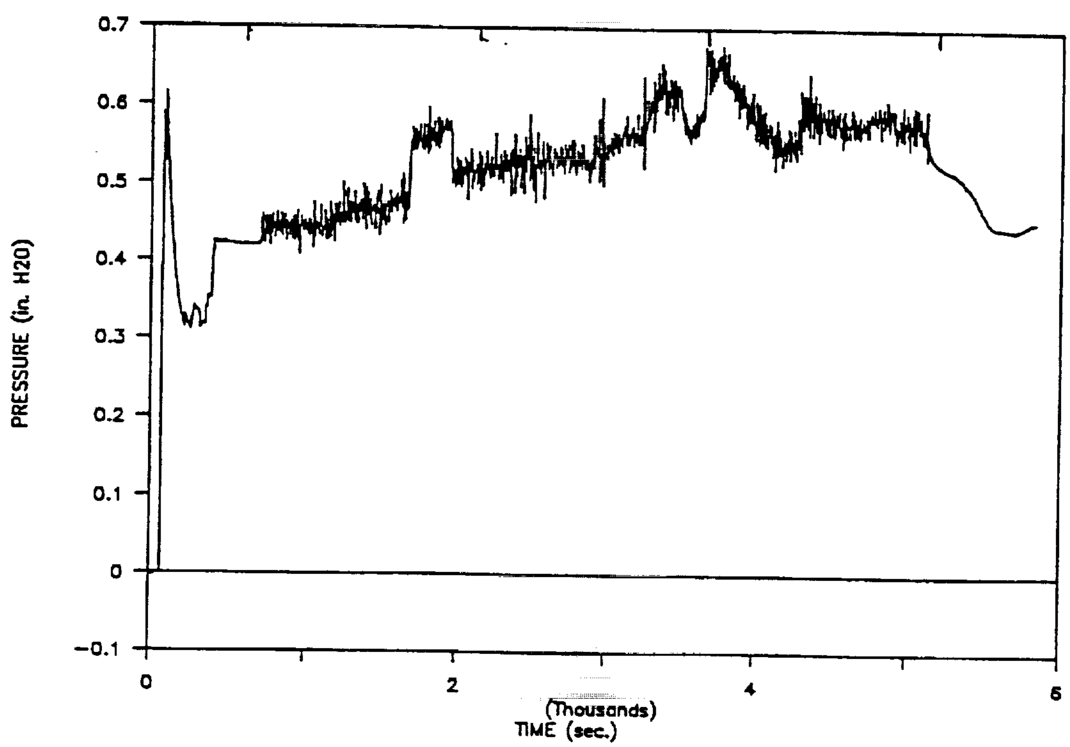


Figure 15. Purge chamber pressure at pressure sensor #2 during keyhole weld of HP9-4-30 on ten foot dia. ASRM ring

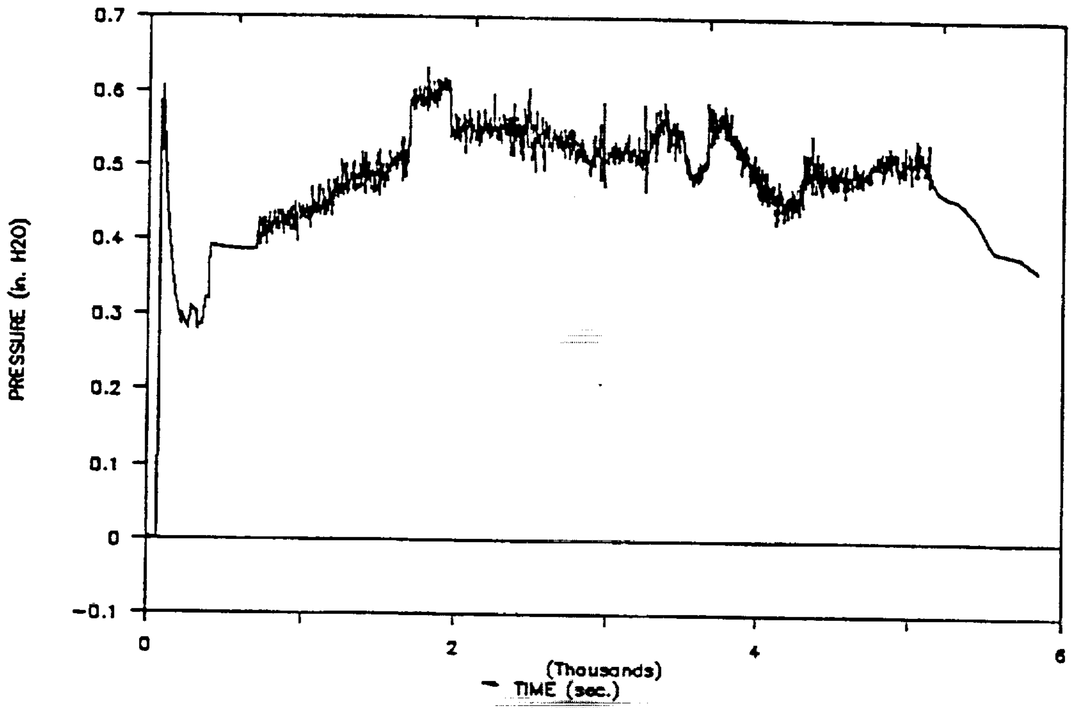


Figure 16. Purge chamber pressure at pressure sensor #3 during keyhole weld of HP9-4-30 on ten foot dia. ASRM ring

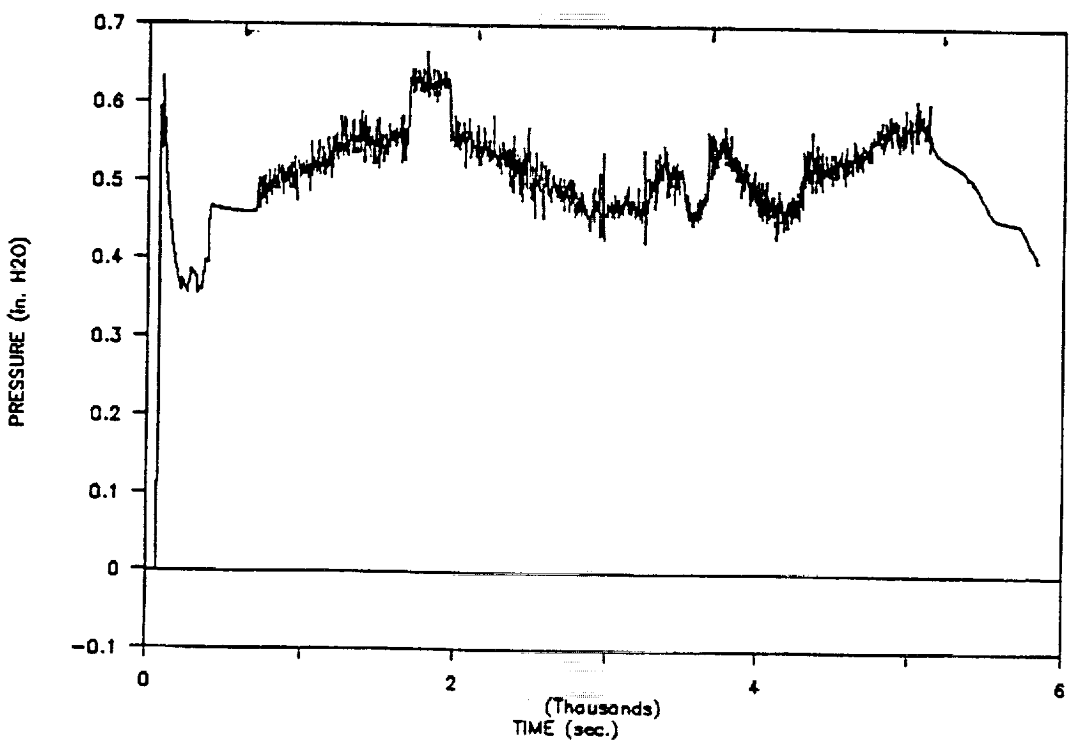


Figure 17. Purge chamber pressure at pressure sensor #4 during keyhole weld of HP9-4-30 on ten foot dia. ASRM ring

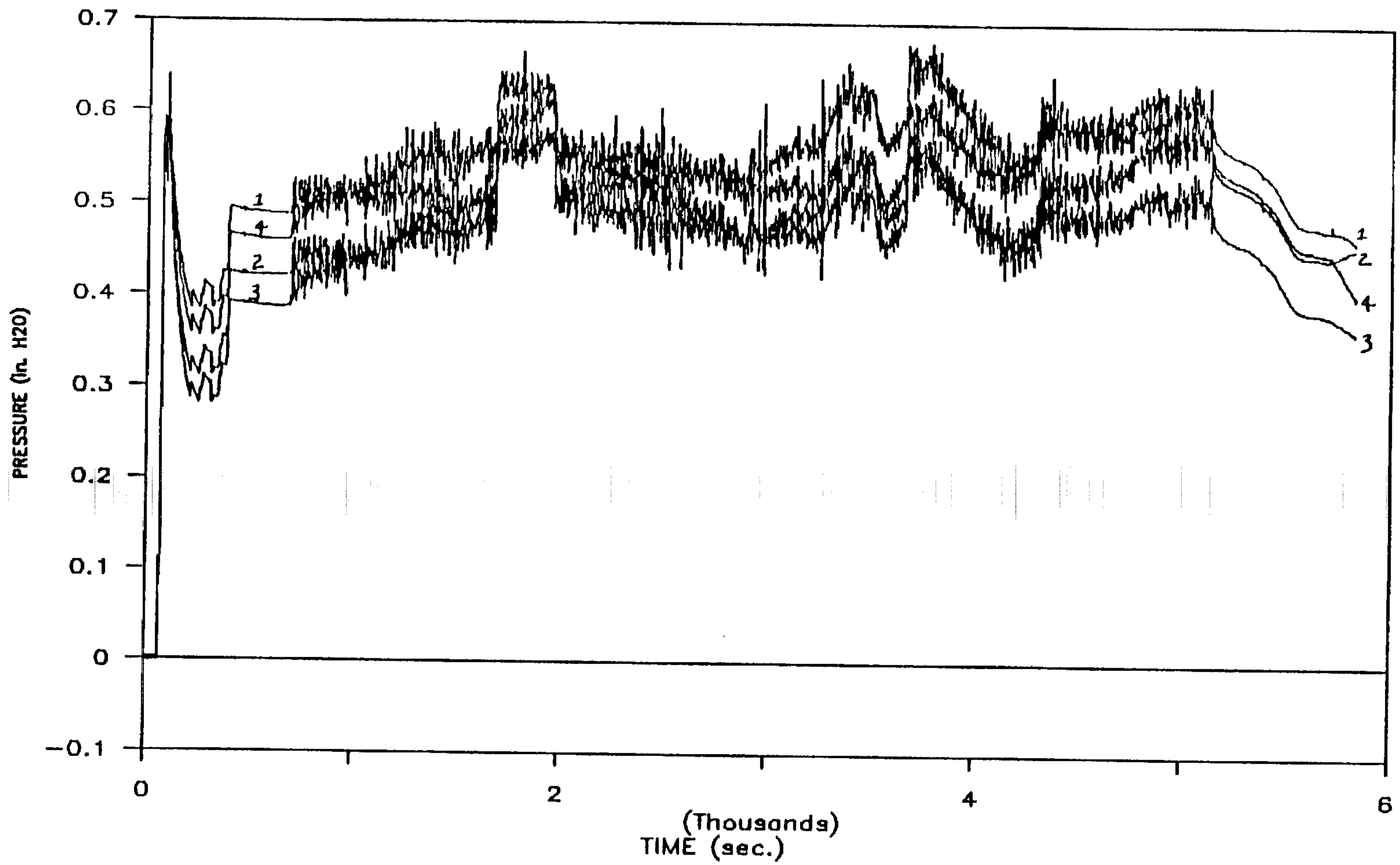


Figure 18. Purge chamber pressure at pressure sensors #1, #2, #3, and #4 during keyhole weld of HP9-4-30 on ten foot dia. ASRM ring

7.0 Conclusions

The major conclusions resulting from this development effort are listed below.

- Controlling the purge process in small (< 24 in. long) chambers is possible without adaptive control for both the flat and vertical welding positions.

- When using the pressure sensing capabilities of the prototype backside purge control system the initiation and termination of the plasma keyhole can be detected in both large and small chambers.

- The backside purge control system developed in this effort has the capability of monitoring and controlling the purge process based on chamber pressure, oxygen content, or a combination of the two.

- The data acquisition capability of the controller developed in this effort makes it an excellent tool for analyzing the backside purge process.

8.0 Recommendations

It is recommended that NASA utilize the prototype backside purge control system to develop purge techniques for the new ten foot diameter purge chamber. The data acquisition capability it provides will be very useful in analyzing purge conditions for a variety of control techniques and if adaptive control is required this system can implement that control.

It is also recommended that NASA utilize this system to evaluate the new purge chamber designs and techniques currently under development.

ATTACHMENT A

BACKSIDE PURGE CONTROLLER OPERATION

BACKSIDE PURGE CONTROL OPERATION

A brief description of Backside Purge Controller (BSPC) operation is given below. The BSPC configuration defines the address and boundary conditions associated with each BSPC sensor and actuator (valve). The Data Acquisition screen provides the user with real-time information on the sensor outputs, allows switching the logging and control functions (on/off), and provides manual actuation of the control valves. all of these features are discussed below.

BACKSIDE PURGE CONTROLLER CONFIGURATION

FILE NAME: C:\bspc\bspclog.cfg

"Editor" can be used to edit this file. Once in the C:\bspc directory type "editor bspclog.cfg" to edit the configuration file. Detailed instructions on the operation of "Editor" can be obtained by typing "^J".

The following is a description of the configuration screen, a typical configuration is shown in Figure 1.

LOG INTERVAL is the time interval, in seconds, between data entries into the log file. The max. logging frequency is 2 Hz (.5 seconds).

CONTROL INTERVAL is a variable that can be used to implement a programed control action. A control interval of 10 seconds would implement the control action every 10 seconds.

OUTPUT FILE is the name of the file data is logged to.

Sensor Configuration

This block of data defines the analog channel for sensor output, the max. and min. output in engineering units, the name of the output as shown in the log file, and the units of the output.

O2 SENSOR SELECTION refers to the location at which O_2 concentration is being monitored. Nine locations (0-8) are possible via the nine valve manifold.

```
     c:\bspc\bspclog.cfg  chr=1   col=1
LOG INTERVAL         =2.0
CONTROL INTERVAL     =570
OUTPUT FILE          = 9-11-#1

CHAN 0 =BOARD:1, CHANNEL:0, MAX:25, MIN:0, OFFSET:0.000, NAME:OXYGEN, UNITS:% O2
CHAN 3 =BOARD:1, CHANNEL:3, MAX:2,MIN:0, OFFSET:0.133, NAME:Gas pressure 1, UNITS:In of Water
CHAN 4 =BOARD:1, CHANNEL:4, MAX:2,MIN:0, OFFSET:0.050, NAME:Gas pressure 2, UNITS:In of Water
CHAN 5 =BOARD:1, CHANNEL:5, MAX:2,MIN:0, OFFSET:0.074, NAME:Gas pressure 3, UNITS:In of Water
CHAN 6 =BOARD:1, CHANNEL:6, MAX:2,MIN:0, OFFSET:0.061, NAME:Gas pressure 4, UNITS:In of Water
CHAN 7 =BOARD:1, CHANNEL:7, MAX:2,MIN:0, OFFSET:0.014, NAME:Gas pressure 5, UNITS:In of Water
CHAN 8 =BOARD:1, CHANNEL:8, MAX:2,MIN:0, OFFSET:0.015, NAME:Gas pressure 6, UNITS:In of Water
CHAN 9 =BOARD:1, CHANNEL:9, MAX:2,MIN:0, OFFSET:0.030, NAME:Gas pressure 7, UNITS:In of Water
CHAN 10=BOARD:1, CHANNEL:10,MAX:2,MIN:0, OFFSET:0.035, NAME:Gas pressure 8, UNITS:In of Water
CHAN 11=BOARD:1, CHANNEL:11,MAX:2,MIN:0, OFFSET:0.194, NAME:Gas pressure 9, UNITS:In of Water

OXYGEN SENSOR SELECTION = 0

O2 VALVE 1 = BOARD:0, CHANNEL:0
O2 VALVE 2 = BOARD:0, CHANNEL:3
O2 VALVE 3 = BOARD:0, CHANNEL:2
O2 VALVE 4 = BOARD:0, CHANNEL:1

INLET VALVE 1 = BOARD:2, CHANNEL:3
INLET VALVE 2 = BOARD:2, CHANNEL:2
INLET VALVE 3 = BOARD:2, CHANNEL:1
INLET VALVE 4 = BOARD:2, CHANNEL:0

PORT = 2
BAUD = 38400
```

Figure 1. BSPC Configuration

O2 VALVE defines the digital output address of the O_2 valves on the manifold. Only 4 were used in past experiments.

INLET VALVE defines the digital output address of the four shield gas inlet valves.

LOGGING DATA

DATA ACQUISITION SCREEN

C:\bspc\bspclog

This screen displays the current output value of the oxygen sensor and nine pressure sensors. It also displays the status (on/off) of the four oxygen valves and four shield gas inlet valves. A typical log screen is shown in Figure 2.

logging is toggled on and off using the **L** key and control is toggled using the **C** key.

Before logging is started it is recommended that the pressures sensors be zeroed by adjusting the offset in the configuration file. This should be done while all sensors are exposed to atmospheric pressure.

```
BackSide Purge Data Log, Vers 3.0 Elapsed time: 0.0, Oxygen input: 0

Oxygen          :20.751        %O2
Gas pressure 1 : -0.001        Inches of Water
Gas pressure 2 : -0.005        Inches of Water
Gas pressure 3 : -0.004        Inches of Water
Gas pressure 4 : -0.001        Inches of Water
Gas pressure 5 : -0.003        Inches of Water
Gas pressure 6 : -0.002        Inches of Water
Gas pressure 7 : -0.001        Inches of Water
Gas pressure 8 : -0.003        Inches of Water
Gas pressure 9 : -0.007        Inches of Water

(L) - Logging: OFF
(C) - Control: OFF

      O2 Valve                 Inlet Valve
 1    2    3    4      1    2    3    4
OFF  OFF  OFF  OFF    OFF  OFF  OFF  OFF
 F1   F2   F3   F4     F5   F6   F7   F8      Press ESC to stop
```

Figure 2. BSPC Data Acquisition

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16. Abstract

New light-weight aluminum-lithium alloys are being considered for propellant tank and aerospace structural applications. These alloys require more precise control of the welding atmosphere. Atmospheric oxygen contamination must be eliminated by flooding both the front and back sides of the weldment with an inert gas. This gas must be maintained at a desired pressure and flow rate that does not effect the stability of the weld process.

The objective of the prototype backside purge control system being developed by NRC is to monitor and regulate the backside purge process and to develop a purge chamber design that enhances process controllability. This project will be conducted in two phases. The objective of Phase I is to develop a purge technique concept based on an investigation into the backside purge process. Phase II will evaluate the backside purge concept developed in Phase I.

17. Key Words (Suggested by Author(s))

VPPA, PROCESS CONTROL, BACKSIDE PURGE, ALUMINUM-LITHIUM

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