NASA/CR-97- 206459

Final

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IN-54-CR
OCIT
125738

Water Processor and Oxygen Generation Assembly

Contract H-29387D

Final Report

December 5, 1997

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Prepared by
UNITED TECHNOLOGIES CORPORATION
HAMILTON STANDARD SPACE SYSTEMS INTERNATIONAL, INC.
WINDSOR LOCKS, CONNECTICUT 06096

Prepared by: John Bedard

Approved by: Engineering Manager (OGA)

Approved by: Engineering Manager (WP)

Approved by: Program Manager

1.0 Introduction:

This report documents the results of the tasks which initiated efforts on design issues relating to the Water Processor (WP) and the Oxygen Generation Assembly (OGA) Flight Hardware for the International Space Station. This report fulfills the Statement of Work deliverables requirement for contract H-29387D.

The following lists the tasks required by contract H-29387D:

1. HSSSI shall coordinate a detailed review of WP/OGA Flight Hardware program requirements with personnel from MSFC to identify requirements that can be eliminated without affecting the technical integrity of the WP/OGA Hardware.

2. HSSSI shall conduct the technical interchanges with personnel from MSFC to resolve design issues related to WP/OGA Flight Hardware.

3. HSSSI will initiate discussions with Zellwegger Analytics, Inc. to address design issues related to WP and PCWQM interfaces.

2.0 Major accomplishments during the reporting period:

2.1 Initial requirements review:

HSSSI conducted several internal reviews of the WP/OGA Flight Hardware technical and programmatic requirements. The result of these reviews was a list of questions, issues and assumptions.

HSSSI has submitted this list to MSFC that will serve as a basis of generating the specification and ICD requirements for the WP/OGA Flight Hardware. Within this list are recommendations and assumptions to provide reduced requirements without effecting the integrity of the hardware.

A study of data items (DI) that are currently required on several other NASA programs has been conducted. This list along with HSSSI's recommendations for the flight program DIs will be provided at the TIM scheduled in December. The goal is a list of DIs that will minimize the cost to the program.

2.2 Technical Interchange Meeting

A Technical Interchange Meeting (TIM) was conducted at MSFC on November 19, 1997. Attachment I is a copy of the slide presented. The presentation covered the following topics: program schedule milestones, pre-start tasks, specification and ICD questions / issues, MSFC SOW, Data Items, EEE Parts, and OGA Power Supply. A near term schedule was developed and agreed to at the meeting and is provided in figure 1.

As a result of the TIM an Action Item List was generated and is in figure 2

OGA & WP
Near Term Schedule

- Contract 1 ATP 11/7/97
- Technical and Business Meeting at MSFC 11/19/97
- TIM #1 at MSFC for Requirements Development 12/16-18/97
- TIM #2 at SSI for Requirements Development 1/13-15/98
- Draft B1 System Specifications & CEI Specifications 1/15/98
- Draft Interface Control Documents 1/15/98
- Baseline System Schematics 2/24/98
- Draft Statement of Work 3/1/98
- Program Requirements Review at MSFC 2/24-26/98

FIGURE 1

WATER PROCESSOR/OGA ACTION ITEM LIST

TECHNICAL MEETING 11/19/97

ACTION ITEM NO.	*DESCRIPTION*	*DUE DATE*	*PERSON RESPONSIBLE*	*STATUS*
1	Provide spec software (Doors) info to MSFC	12/1/97	B.Kundrotas	Closed 11/21/97
2	SSI recommendation on Program Data Items including DI description	12/15/97	D. Cloud/D. Parker	
3	MSFC response in writing on spec and ICD issues/questions	12/15/97	B. Bagdigian	
4	Draft "SOW" for OGA Power Supply	12/15/97	D. Cloud	

FIGURE 2

2.3 Zellweger Analytics, Inc.

HSSSI has initiated discussions with Zellweger Analytics, Inc. to address design issues related to WP and PCWQM interfaces. HSSSI and Zellweger conducted telephone conversations on Nov. 6 and 13, 1997 to review program status and history. These telecons were in preparation for TIM held at MSFC on Nov. 20, 1997 with HSSSI and MSFC in attendance. The minutes of the meeting are provided in Attachment III. Please note that financial data contained in minutes have been removed from Attachment III for this submittal. Topics included in Zellweger/s presentation were PCWQM status, schedule, design issues, manpower requirements, and a review of the recent trade study efforts funded by MSFC. In additional, Zellweger discussion included the iodine and conductivity sensor assembly (CISA) program conducted for Boeing following the PCWQM program shutdown. This assembly was investigated for potential implementation into the WP and OGA system designs.

3.0 Additional Tasks

During this contract period, HSSSI has initiated additional tasks to support the items in the Statement of Work:

1. Internal schematic reviews on both the WP and OGA have been initiated.
2. Computer models of the WP and OGA schematics have been initiated.
3. Review of RIDs from WP PDR held in March, 1992.
4. Program Planning Tasks such as development of the initial program organization, identifying preliminary work breakdown structures, configuration control planning, and data rights reviews.

4.0 Conclusion

HSSSI has fulfilled the requirements of the Statement of Work for Contract H-29387D. The dialogues initiated between MSFC, HSSSI and Zellwegger have been informative and productive..

ATTACHMENT I

Oxygen Generator Assembly

and

Water Processor

Technical Meeting

at

Marshall Space Flight Center, Huntsville

November 19-20, 1997

OGA & WP Technical Meeting

List of HS Attendees

Dale Cloud - Project Engineering Manager (OGA) (11/19)
Dave Parker- Project Engineering Manager (WP) (11/19-20)
Mike O'Toole - Lead Electrical Design (11/20)
Lynn Rollins - Purchasing Manager (11/20)
Mike Stanley - Program Manager (11/19-20)
Rich Mason - Field Engineer (11/19)
Mike Tosca - Subcontract Program Manager (11/19-20)
Kevin Grohs - Contracts (11/19)
Dexter Wheelock - Financial (11/19)
Donna Grossman - Mechanicl Design (11/19-20)

OGA & WP Technical Meeting

Agenda

<u>Wednesday, November 19-1:00-4:30</u>

Organization Charts (MFSC & HS)
Schedule Milestones
Pre-Start Tasks
Specification Issues
ICD Issues
MSFC SOW/ Preliminary List of Data Items
EEE Parts
OGA Power Supply
System Schematics
OGA Tour at 4755

OGA & WP Technical Meeting
Agenda

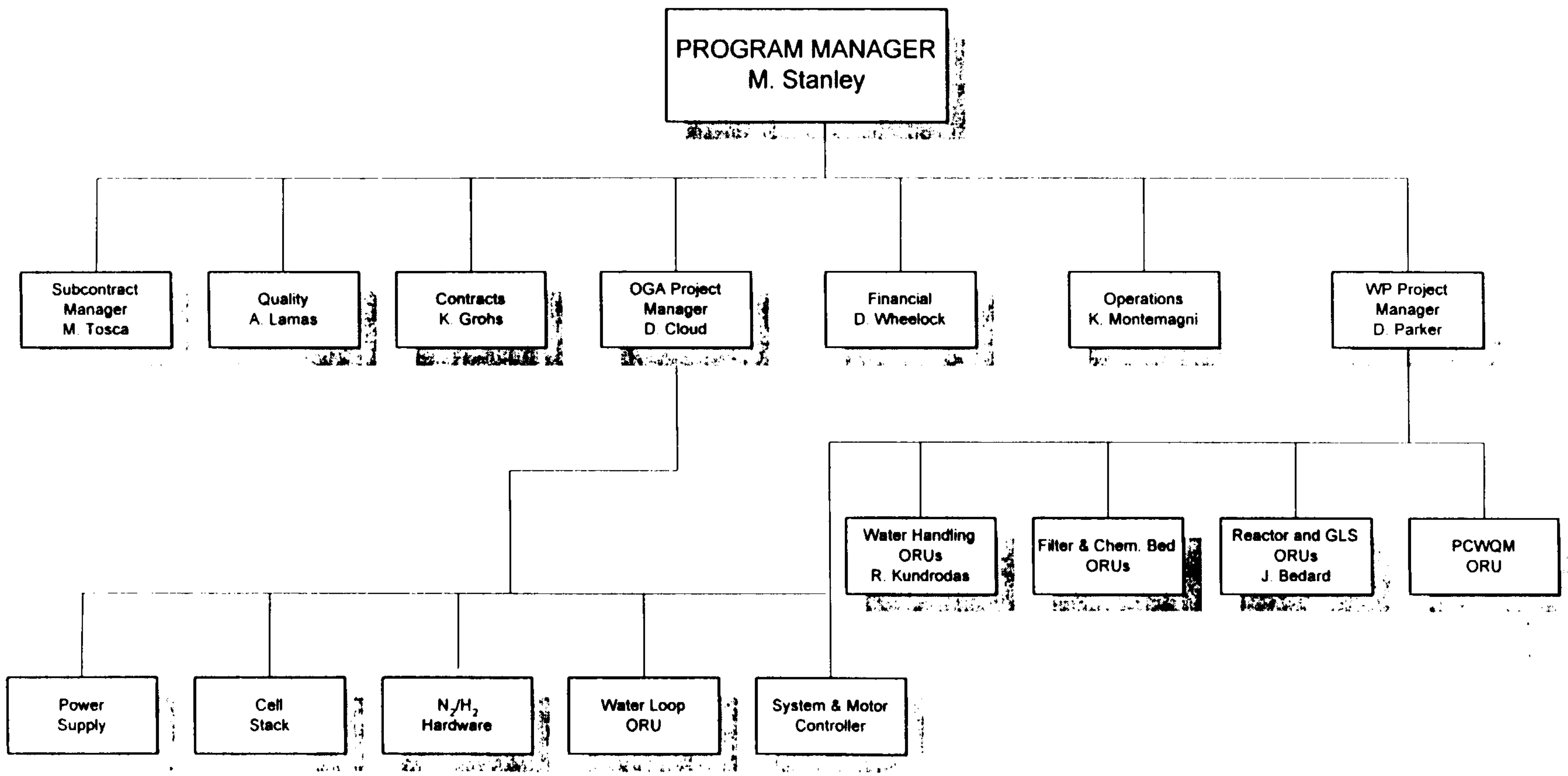
<u>Thursday, November 20-8:30-4:00</u>

Zellweger Analytic Presentation

- PCWQM
  - Status
  - Design
  - Issues
  - Schedule
- I2/Conductivity Sensor
  - Status
  - Design
  - Issues
- Contract Issues (HSSSI & Zellweger)
- Manpower (HSSSI & Zellweger)

(HS- D. Parker, L. Rollins, M. Stanley, M. O'Toole, M. Tosca, D. Grossman)

OGA & WP Technical Meeting
Preliminary Organization Chart



OGA & WP Technical Meeting
Near Term Schedule

- Contract 1 ATP 11/7/97
- Technical and Business Meeting at MSFC 11/19/97
- TIM #1 at MSFC for Requirements Development ________
- TIM #2 at SSI for Requirements Development ________
- Draft B1 System Specifications ________
- Draft Interface Control Documents________
- Finalize System Schematics________
- Issue Statement of Work________

OGA & WP Technical Meeting
Schedule Milestones

- Contract 1 ATP 11/7/97
- WP GLS CR&D Contract ATP 11/97
  - Technology Trade Study
  - Hardware Procurement and Test
  - Deliver Prototype Hardware to MSFC 7/98
- System Requirements Definition 11/97-2/98
- Receive RFP 2/98
- Flight Contract ATP 7/98
- OGA PDR 8/98
- WP Delta PDR 8/98
- ISS WP vs JSC ALS Decision Point 1/99
- CDR 3rd Quarter 99
- System Delivery 7/01
- Node 3 Launch 7/02

OGA & WP Technical Meeting

Pre-Start Tasks

Contract 1 & 2

- Program Planning
- System Specification
- ICD
- Initial Design Tasks

OGA & WP Technical Meeting

Pre-Start Tasks

- Program Tasks -Contract 1
  - Internal Kickoff Meeting November 13, 1997
  - PD for Contract 1
  - PDR Info and RID Review (WP)
  - Final Report, December 1997

OGA & WP Technical Meeting

Pre-Start Tasks

- Program Planning-Contract 2
  - Issue Program Directives
  - Proprietary Notification List
  - Detailed Manpower Plan
  - Continue Detailed Schedule Planning
  - Finalize WBS Structure
  - Documentation-POP, Q Plan, M&P Plan, Mfg Plan, etc.

OGA & WP Technical Meeting

Prestart Tasks

- System Specifications-Complete Jan 1998
  - TIM at MSFC for Requirements Review-Contract 1
  - Resolve AI's from TIM-Contract 1
  - TIM at SSI for specification development-Contract 2
  - Write and issue B1 system specification-Contract 2
  - Weight, power and volume studies, for specification input-Contract 2

OGA & WP Technical Meeting

Prestart Tasks

- Interface Control Document (ICD)- Complete Feb 1998
  - TIM at MSFC ICD Issues Review-Contract 1
  - Resolve AI's from TIM-Contract 1
  - Assist MSFC in ICD preparation-Contract 2

OGA & WP Technical Meeting

Prestart Tasks-OGA

- Initial Design Tasks
  - Review OGA System Schematic-Contract 1
  - Finalize OGA System Schematic, Nov 1997-Jan 1998-Contract 2
    - Safety Review
    - Determine location of I/X bed
    - Computer model for system dynamics
  - Component Specifications Dec 1997-Jan 1998-Contract 2
    - Revise mini specifications
    - Bellows tanks

OGA & WP Technical Meeting
Prestart Tasks-OGA

- Initial Design Tasks (continued)
  - Preliminary Parts and Drawings Lists, Jan 1998-Contract 2
  - Motor Controller Topology & Packaging Study, Nov 1997-Jan 1998-Contract 2
  - Controller Evaluation and Make Buy Study, Nov 1997-Jan 1998-Contract 2
  - Power Supply Interface Definition-Contract 1

OGA & WP Technical Meeting

Prestart Tasks-WP

- Initial Design Tasks
  - Review WP System Schematic-Contract 1
  - Finalize WP System Schematic, Nov 1997-Jan 1998-Contract 2
    - Liquid and gas sensor alternate concepts
    - Waste water and delivery schematic trades
    - Scrubber for MLS gas outlet
    - Removal of the sterilization ORU
    - Evaluate addition of a flow sensor or monitor tank quantity
    - Evaluate alternate location of conductivity sensors
    - Computer model for system dynamics

OGA & WP Technical Meeting

Prestart Tasks-WP

Initial Design Tasks (continued)

- Component Specification, Dec 1997-Jan 1998-Contract 2
  - Revise mini specifications
  - Bellows tanks
- PDR Status/Design, Nov-Dec 1997-Contract 2
  - Review RID status
  - Develop list of PDR open issues and review for current action
- Preliminary Parts and Drawings Lists, Jan 1998-Contract 2
- Motor Controller Topology & Packaging Study, Nov 97-Jan 1998-Contract 2
- Controller Evaluation and Make Buy Study, Nov 97- Jan 1998-Contract 2

OGA & WP Technical Meeting

Prestart Tasks-WP

- Initial Design Tasks
  - PCWQM-Zellweger CDR Presentation, Dec 1997
    - Review CDR and program documentation -Contract 1
    - Attend TIM/CDR presentation at MSFC, Nov 20, 1997-Contract 1
    - Quality survey of Zellweger, Dec 1997-Contract 2
    - TIM at Zellweger's to continue technical/programmatic discussions, Dec 1997-Contract 2

OGA & WP Technical Meeting

Specification Issues

- See attached sheets

QUESTIONS/COMMENTS FOR MSFC
11/18/97

SPECIFICATION QUESTIONS/COMMENTS:

- Utilize the latest revision SSP documents. Some of these suggested documents are:
    - Electrical power - SSP 30482, Vol. 2
    - Materials/Processes - SSP 30233
    - EEE Parts - SSP 30312 & SSP 30423
    - Electromechanical Radiation - SSP 30237 (Testing - SSP 30238)
    - Grounding - SSP 30240
    - Bonding - SSP 30245
    - Cable/wire Design - SSP 30242
    - Workmanship - NHB series
    - Human Performance/Human Engineering - SSP 50005
    - Structural - SSP 30559
    - Fracture Control - SSP 30558
    - Reliability - Ex: FMEA/CIL SSP 30234
    - Safety - Ex.: Safety Hazard Analysis SSP 30309
- What are the Classification of Characteristics requirements?
- Are we required to use the Boeing quick disconnects?
- We are assuming the edge break (or radii) requirements of SSP50005 (not NASA-STD-3000).
- Does MSFC have any hydrogen safety requirements, design standards, explosion pressure factors, and/or ventilation requirements?
- What are the maintenance requirements?
- Are blind-mate quick disconnects and/or electrical connectors acceptable?
- Does MSFC have any preferred or recommended common hardware, such as:
    - slides
    - quick disconnects
    - valves
    - sensors
    - flex lines
    - electrical connectors
    - fasteners
- Are there any fastener preload/torque analysis requirements?
- HS to have the capability to define the verification methodology for each shall statement subject to MSFC approval
- Need operational timeline profiles for water usage on ISS.
- HS recommends NC-55 for acoustic requirement. Rack panels provide attenuation against the NC-50 station requirement.
- How will the systems be shipped to MSFC (as a system or as ORU's)?
- MSFC to define minimum expendable life.
- Establish performance requirements when the system is exposed to low ambient pressure 9.0 Psia and 10.0 to 10.6 psia operation for 1095 days.
- Verify inlet waste water system filtration level is 100 micron.

QUESTIONS/COMMENTS FOR MSFC
11/18/97

- HS will develop specifications utilizing MIL-STD-490.
- HS is assuming the following failure tolerance:
  - 0 fault tolerant for function (i.e. fail safe)
  - 1 fault tolerant for critical failures
  - 2 fault tolerant for catastrophic failures
  - 1 fault tolerant for marginal failures
- What are the weight, power, volume requirements for each system?

RELIABILITY/SAFETY QUESTIONS:

- What is the functional criticality of the systems?
- If the system fails, what actions would be taken? What are the backups?
- Will the controller be considered one fault tolerant under the proper design conditions? (such as watch dog timers, periodic ram/rom tests, separation of critical redundant signals)
- Is there a space station atmospheric monitor that would backup the OGA so far as detecting hydrogen below the lower explosive limit?

QUESTIONS/COMMENTS FOR MSFC
11/18/97

MECHANICAL DESIGN QUESTIONS/COMMENTS

Rack questions/comments:

- What is the exact double rack configuration? We need drawings ASAP.
- Where are the rack keep-out volumes?
- Where are the allowable attachment points?
- What size and configuration are the attachment points?
- What is the total load bearing capacity of the rack? We need this value for racks both with and without the centerpost.
- Is there a load limit per post?
- Is there a load limit per attachment bolt?
- Where is the interface panel (at the stand-off) and what is its configuration? What are the electrical and fluid interface configurations?
- What is the expected rack structure deflection (i.e., what clearance is required between the hardware and the rack)?
- Is there a CG location requirement?
- What electrical bonding provisions are provided in the rack?

Packaging questions/comments:

- Our assumption is that if an Avionics Air Assembly is required, it is not part of our packaging volume.
- Besides front access, what other maintenance access is allowed?
- Is liquid cooling available? What heat rejection capacity is available?
- How much heat can be dumped into the rack?
- We will supply all ducting, tubing, and harnessing required to interface from the interface panel and/or the Avionics Air Assembly to our hardware.

Structural questions/comments:

- What is the natural frequency requirement?
- What are the quasi-static loads?
- What are the random vibration loads?
- Is there a required method for load combination?
- What are the safety factor requirements?
- What are the fracture control requirements?
- Is there a problem with tying across rack corner posts (side-to-side or front-to-back)? In this case, what loads from the rack are inputted into our ORU's?
- Who is responsible for the structural analysis of our ORU's as part of the rack?

OGA & WP Technical Meeting

ICD Issues

- See attached sheets

QUESTIONS/COMMENTS FOR MSFC
11/18/97

Water Processor Interfaces:

Ambient Air
- Temperature Range
- Pressure Range
- Dew Point Range
- Oxygen Concentration Range

Nitrogen (In) (Water Storage ORU) - approximately .5 lbs per day required
- Temperature Range
- Pressure Min.
- Flow Rate Max.
- Dew Point Range

Waste Water (In) (Waste Water ORU)
- Temperature Range
- Pressure Range
- Flow Rate
  - Average Lb/min
  - Peak Lb/min
- Quality (Contaminants/constituents)

Gas Vent (Out) (Waste Water ORU)
- Constituents/properties
- Physical connection

Oxygen Supply (In) (Catalytic Reactor ORU)
- Pressure Min.
- Flow Rate Max.

Gas Vent (Out) (Gas Separator ORU)
- Physical
- Ambient Pressure Range
- Dew Point Range

Product Water Supply (Out) (Water Storage ORU)
- Back Pressure
- Water Quantity Required

Electrical Power
- SSP 30263:002 RPCM Requirements
- SSP 30482, Vol. 1 and Volume 2 Power Requirements

QUESTIONS/COMMENTS FOR MSFC
11/18/97

Data Bus (1553)

Assembly Commands

INITIALIZE	HARD STOP
STANDBY	BIT EXECUTION
OPERATE	REPROCESS
SHUTDOWN	OVERRIDE

Assembly Sensor/Status Feedback (as a minimum)

Fault Status/Isolation (As processed within the embedded controller)

Non-operating Environments by Phase (Transportation, Storage, Prelaunch, Launch, etc)

Temperature	Pressure	Humidity
Vibration	Acceleration	Shock
Acoustics		

QUESTIONS/COMMENTS FOR MSFC
11/18/97

Oxygen Generator Interfaces:

Ambient Air
- Temperature
- Pressure
- Relative Humidity
- Dew Point
- Oxygen Concentration

Nitrogen (In)
- Temperature
- Pressure
- Flow Rate
- Dew Point
- Quality (Contaminants/constituents)

Feed Water (In)
- Temperature
- Pressure
- Flow Rate
- Quality (Contaminants/constituents)

Coolant Water (In)
- Temperature
- Pressure
- Flow Rate
- Quality (Contaminants)

Coolant Air (In) (If any)
- Temperature
- Pressure
- Flow Rate
- Dew Point

Hydrogen Supply (Out)
- Back Pressure

Hydrogen Vent (Out)
- Allowable Purge Gas Mix
- Continuous or Time Restricted
- Rate, Maximum
- Back Pressure

QUESTIONS/COMMENTS FOR MSFC
11/18/97

Oxygen Supply (Out)
- Back Pressure
- Production Rate

Electrical Power (From RPCM to PSM and rest of assembly)
- SSP 30263:002
- SSP 30482, Vol. 1 (Interface C)

Data Bus (MIL-STD-1553B)
- DSBG 9549 ??
- Assembly Commands (Fixed duty cycle and production rate)
  - IMMEDIATE SHUTDOWN
  - ON
  - OFF
  - MANUAL
- Assembly Sensor/Status Feedback
  - Oxygen Pressure
  - Cell Current
  - Cell Voltage
  - Conductivity Sensor (Output)
  - Fault Status/Isolation (As processed within the embedded controller)

Power Supply
- Input Power
- Output Power
- Control/Feedback Signals
- Mechanical Interfaces

Non-operating Environments by Phase (Transportation, Storage, Prelaunch, Launch, On-orbit, Return-to-earth)

Temperature	Pressure	Humidity
Vibration	Acceleration	Shock
Acoustics		

OGA & WP Technical Meeting

MSFC SOW and Data Items

OGA & WP Technical Meeting

EEE Parts

- Reliability Level
- Source

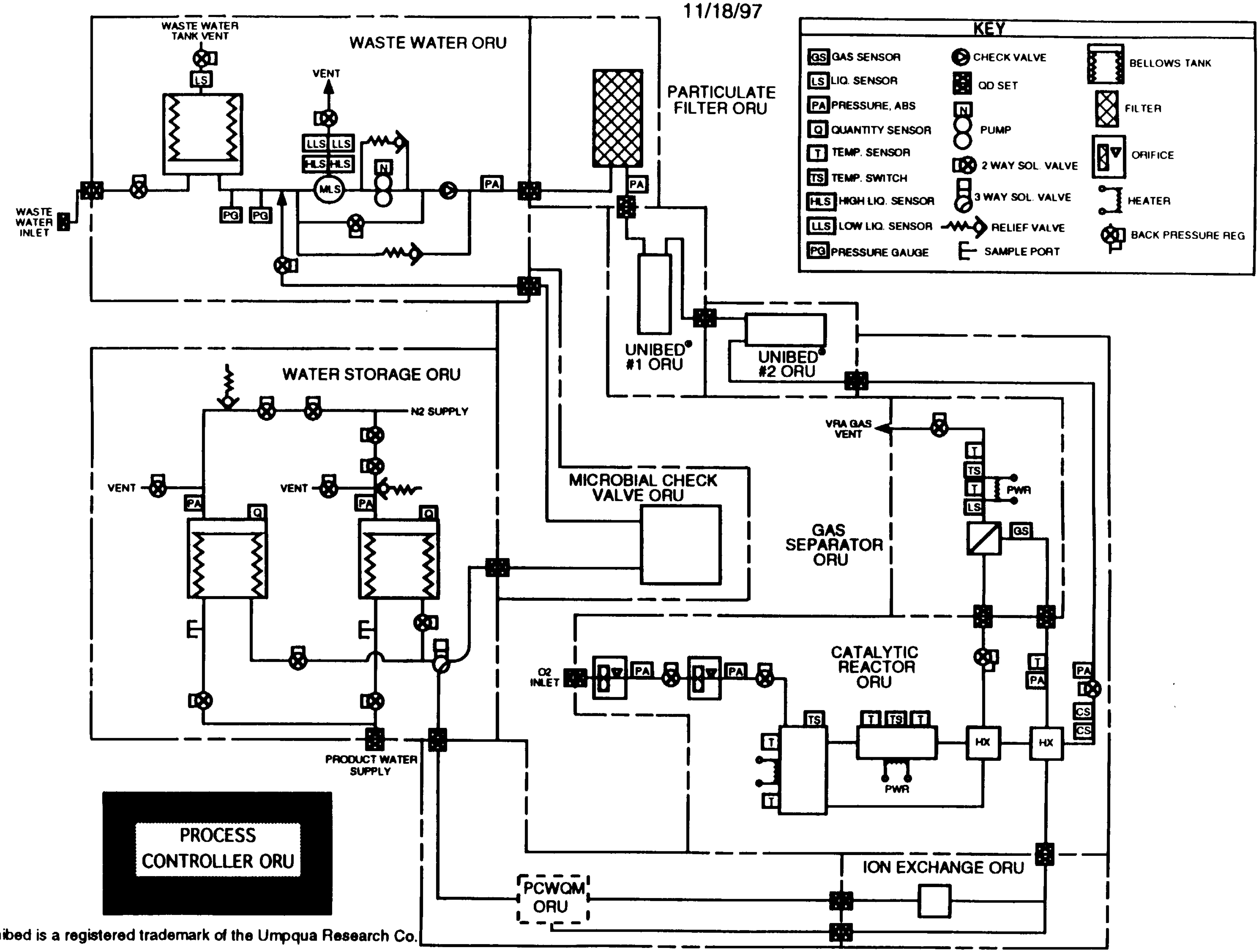
OGA & WP Technical Meeting

OGA Power Supply

- GFE

WATER PROCESSOR (WP) SIMPLIFIED SCHEMATIC

11/18/97



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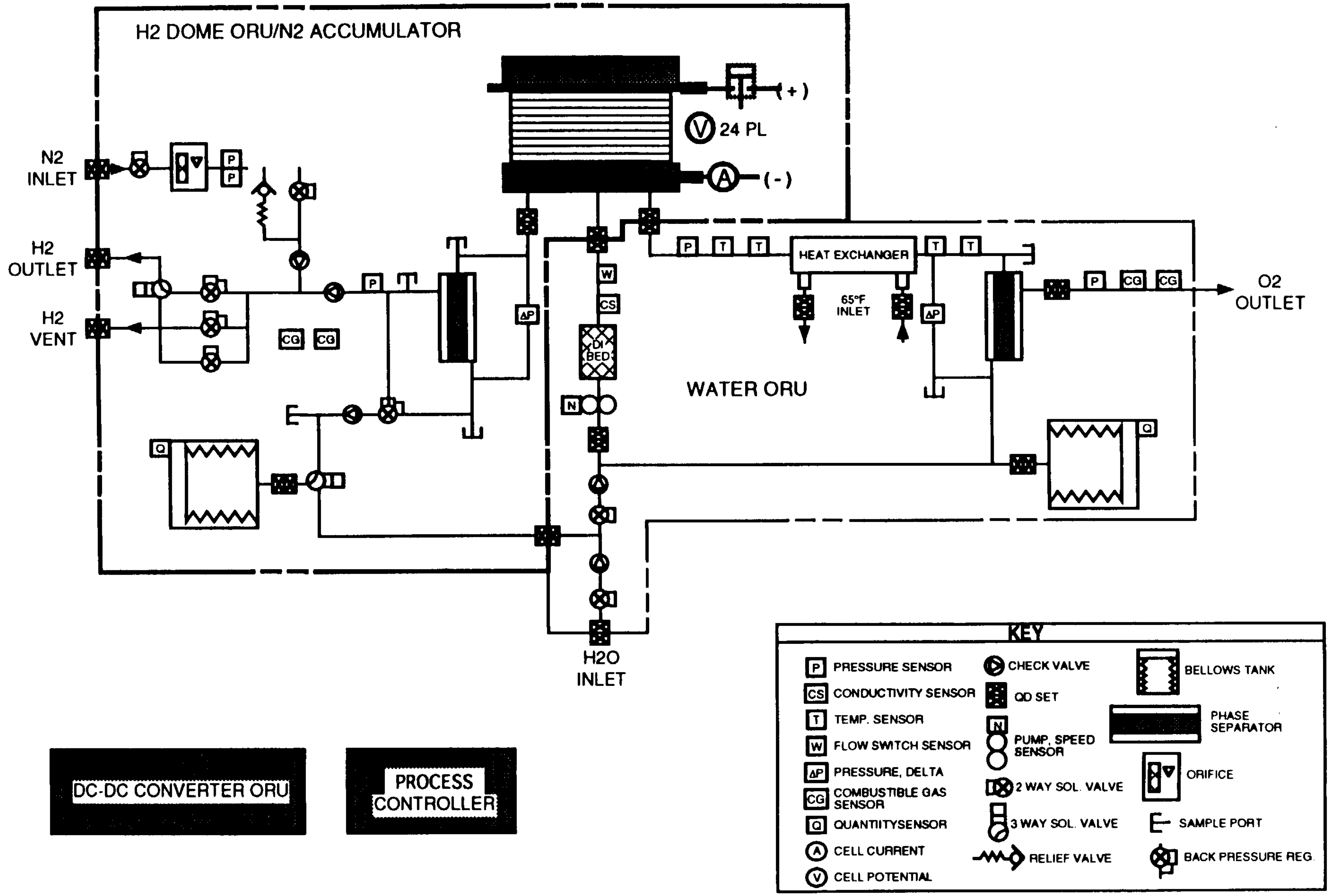
SPE® OXYGEN GENERATOR ASSEMBLY (OGA) FLUID SCHEMATIC (DOME)



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ATTACHMENT II

Zellweger Analytics, Inc.
100 Park Avenue
League City, Texas 77573 USA

Tel: 281 332 2484
Fax: 281 554 6795

zellweger analytics

November 25, 1997
ZA971633

Hamilton Standard
Space Systems International, Inc.
1 Hamilton Road
Windsor Locks, CT 06096-1010
Tel: 860-654-6000

Attention: Ms. Lynn M. Rollins, Purchasing Manager; M/S 1A-3-Z65

Subject: Minutes, International Space Station (ISS) Process Control Water Quality Monitor (PCWQM) Program Technical Interchange Meeting (TIM); November 20, 1997.

Dear Ms. Rollins,

The subject ISS PCWQM TIM Minutes and a copy of ZALC's TIM presentation package are enclosed and are being submitted to you for your information and further distribution as you deem appropriate. ZALC is in the process of working the action items we were assigned at this meeting and will provide responses to you as they become availiable.

Should you have any questions regarding any of the above material, please contact the undersigned at 281-332-2484, Ext. 57.

Regards,

Ken Smith
Program Manager

cc M. Tosla
D. Pater
D. Grossman
M. OToole

cc. (Ltr. & Minutes only)

Mr. Donald L. (Layne) Carter, Mail Stop ED-62
George C. Marshall Spaceflight Center
Marshall Space Center, AL 35812

Subject: Meeting Minutes, International Space Station (ISS) Process Control Water Quality Monitor (PCWQM) Introductory Technical Interchange Meeting (TIM)

Location: Building 4610, Room 5015; George C. Marshall Space Flight Center; Marshall Space Center, AL

Date/Time: November 20, 1997 /(8:30 a.m. to 5:30 p.m.)

Attendees: National Aeronautics and Space Administration/Marshall Space Flight Center (NASA/MSFC):

Bob Bagdigian, ED62; Layne Carter, ED62; Jim Reuter, OB3

Hamilton Standard Space Systems International (HSSSI), Inc.

Windsor Locks, CT - Donna Grossman, Mechanical Engineer; Dave Parker, Project Manager; Lynn Rollins, Purchasing Manager ("Buyer"); Mike Stanley, Program Manager for Water Processor; Michael Tosca, Major Subcontracts Manager.

Huntsville, AL - Rich Mason, Site Technical Representative; Mike O'Toole, Electrical Engineer;

Zellweger Analytics League City (ZALC):

Dale Dougherty, Chief Engineer; Ken Smith, Program Manager

Purpose: The purpose of the meeting was to introduce key members of the NASA/MSFC, HSSSI and ZALC ISS Water Processor (WP) and PCWQM program teams to one another and provide a background and overview of the PCWQM program. Historical prospective was provided for both PCWQM and ICSA Programs as well as discussions for current and future work. Previous telecons regarding restarting the PCWQM contract were held 11-6-97 and 11-13-97.

The was meeting was opened by Mr. Layne Carter who, in turn, introduced the other meeting attendees. These introductions provided a "voice-with-a-face" association and some discussion ensued delineating the rolls these individuals will have in the Water Processor and PCWQM programs. Next, Mr. Dave Parker gave some introductory remarks, presented a meeting Agenda and Schedule, and turned the meeting over to Mr. Ken Smith.

Mr. Smith began with a PCWQM Programmatic presentation (attached) providing Schedule and Manpower charts for the next three years. Discussion took place asking for clarifications where necessary and when Hamilton Standard anticipates funding which can then be used to begin ZALC's PCWQM efforts. Currently a sole source justification describing why Hamilton Standard is the only qualified Water Processor vendor to NASA is being executed by MSFC/NASA. It is anticipated that a Letter Contract between MSFC and HSSSI will be complete on or before

January 1, 1998, at which point HSSSI can formally provide same to ZALC.

Dale Dougherty then went through a PCWQM and ICSA history presentation (attached) describing how the design evolved to the PCWQM-SEU, then to ICSA. The work done for ION Systems was presented and discussed as well as what technical tasks need to be addressed in the near future. Discussion ensued as to why the SEU design should be abandoned in lieu of a 'stand alone' PCWQM and all concurred that the latter, if it can be designed feasibley, makes the most sense.

MSFC electrical design engineers joined the meeting at 1:30 to review the UV Ballast Supply requirements so they can determine if they can provide such a supply to us for incorporation into the PCWQM, as GFE.

Following the UV Power Supply segment of the meeting, Mr. Smith went over the Rough Order of Magnitude (ROM) pricing and related assumptions that ZALC had developed and submitted to NASA/MSFC previously, based on preliminary program requirements and delivery schedules provided by NASA. ZALC's CY98 PCWQM Program manpower figures and pricing data were provided formally to Ms.Lynn Rollins in response to her earlier request for same.

Upon completing the presentation and discussion segments of the meeting, participants adjourned to Bldg. 4655 where they were given a brief tour and overview description of the ECLSS Stage-10 Test Setup by Mr. Layne Carter. The Stage-10 Water Processor (WP) and Process Control Water Quality Monitor (PCWQM) were the focus of this activity.

Action Items resulting from the subject meeting were as follows:

AI#	Assignee	Due Date	Action Item/Task
1	ZALC (DD, KS)	11-24-97	Provide copies of slides presented.
2	ZALC (DD)	12-01-97	Provide copy of UV Lamp drawing for MSFC electrical designers to review.
3	ZALC (DD)	01-15-98	Need Draft of a UV Ballast Power Supply SCD for MSFC
4	ZALC (KS,DD)	01-15-98	Review PCWQM-SEU RIDs from CDR and consider whether they are applicable or OBE.

Ken Smith 11/25/97

Ken Smith, ZALC GPU Program Mngr

Dale Dougherty, ZALC Chief Engr

Dave Parker, HSSSI Project Mngr

Lynn Rollins, HSSSI Purchasing Mngr

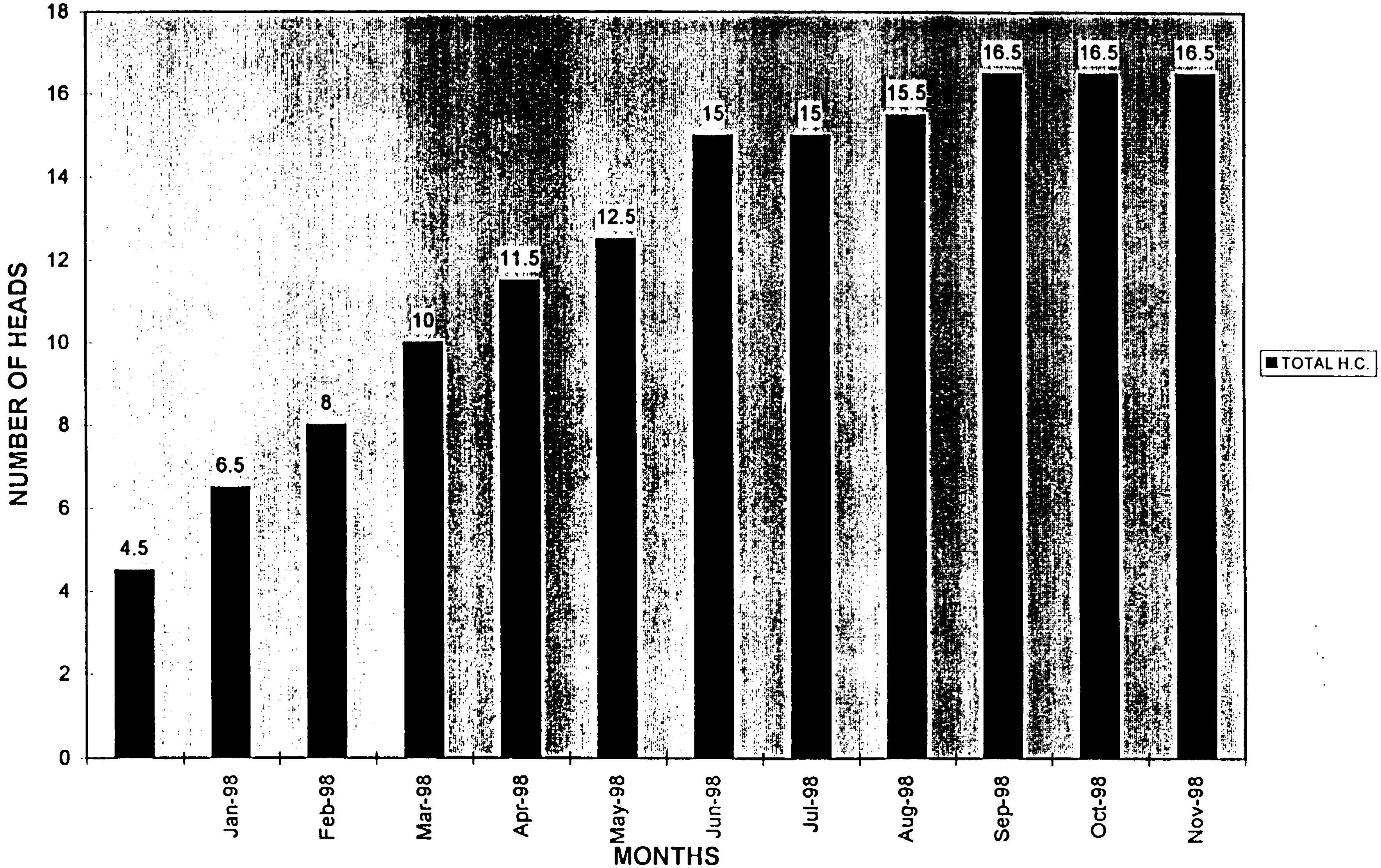
OGA & WP Technical Meeting
Agenda

Thursday, November 20-8:30-4:00

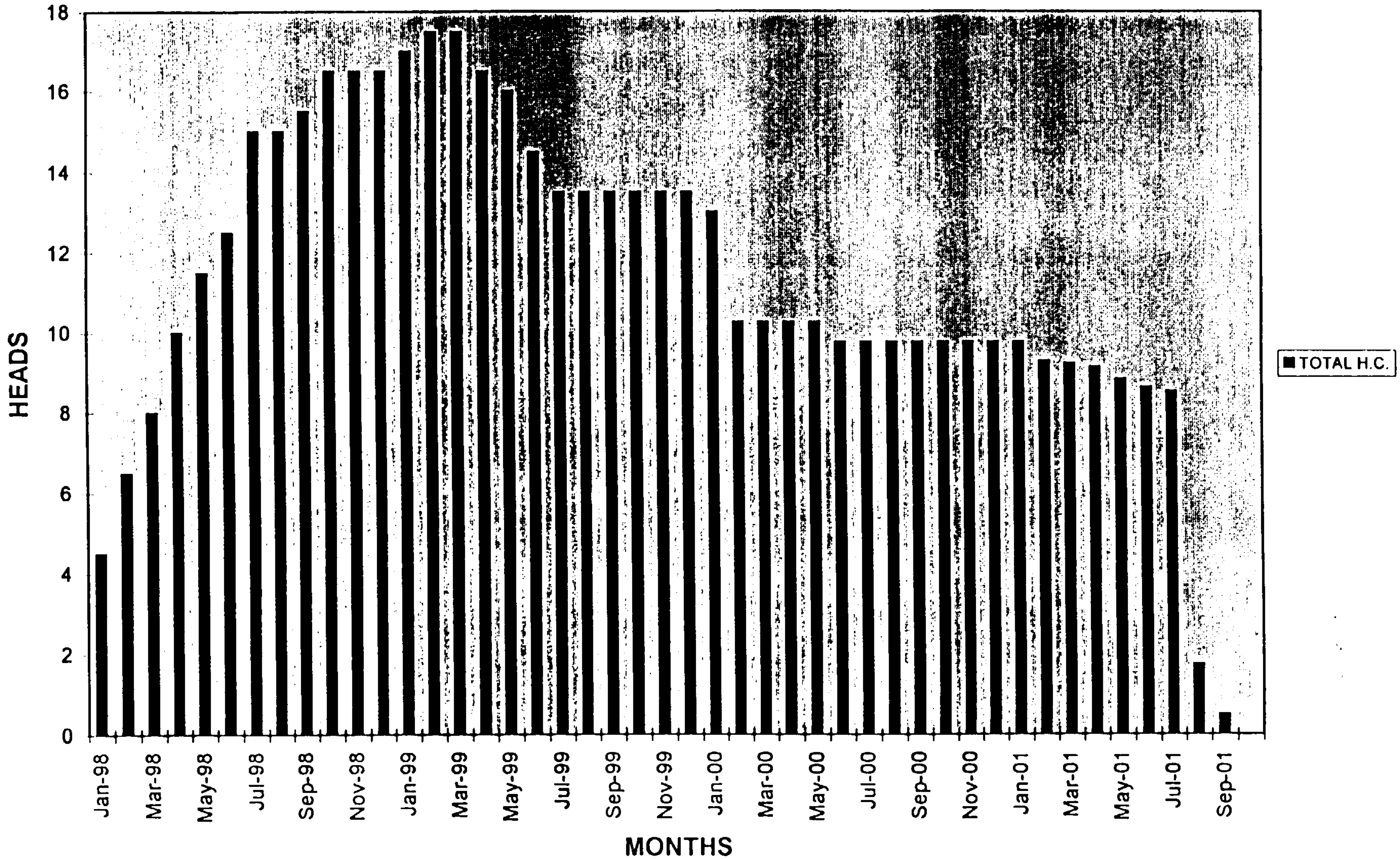
Zellweger Analytic Presentation
- PCWQM
  - Status
  - Design
  - Issues
  - Schedule
- I2/Conductivity Sensor
  - Status
  - Design
  - Issues
- Contract Issues (HSSSI & Zellweger)
- Manpower (HSSSI & Zellweger)

(HS- D. Parker, L. Rollins, M. Stanley, M. O'Toole, M. Tosca, D. Grossman)

PCWQM PROGRAM HEADCOUNT BUILDUP CY-98

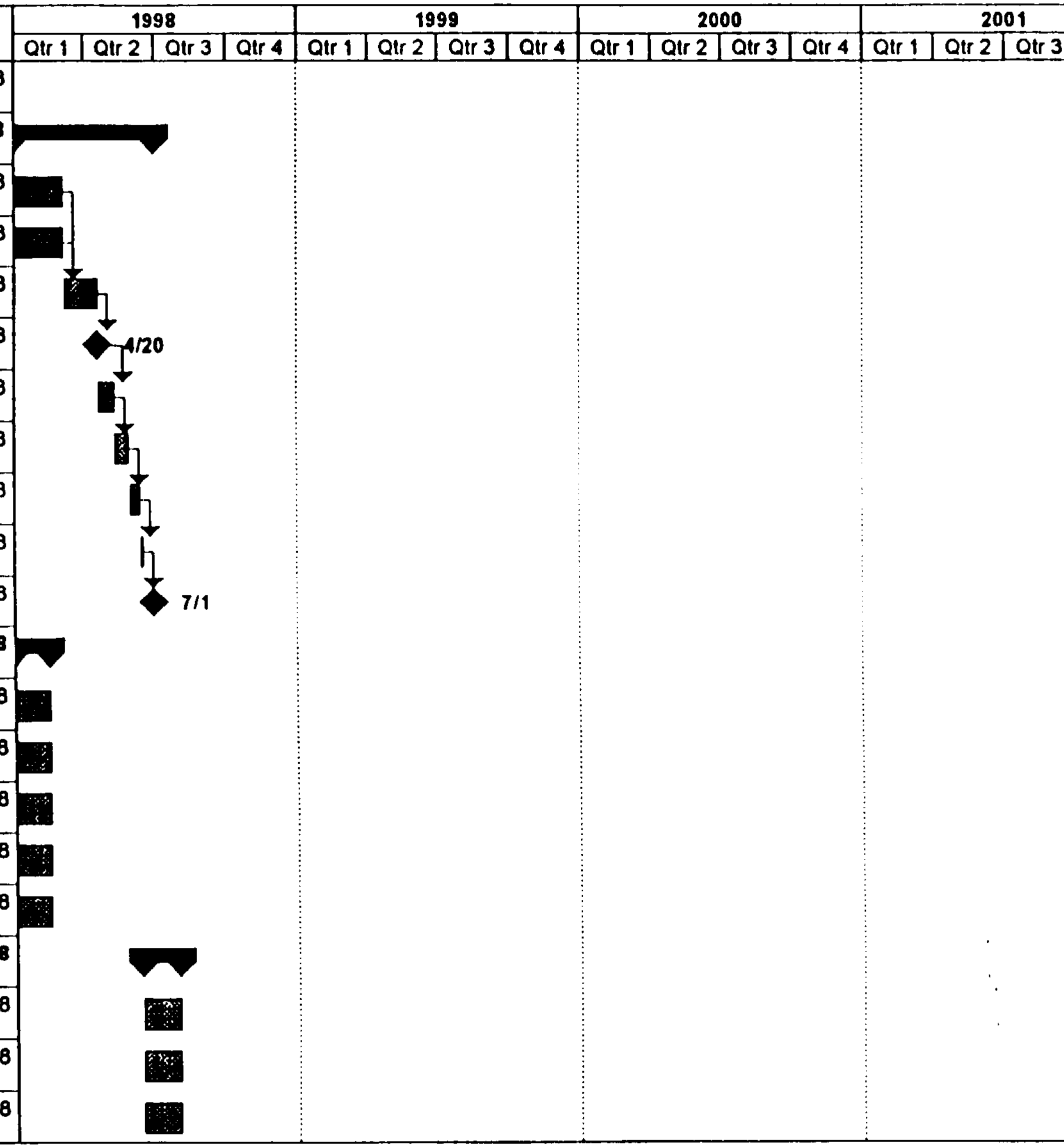


PCWQM PROGRAM HEADCOUNT CY-1998 thru CY-2001



ISS PROCESS CONTROL WATER QUALITY MONITOR (PCWQM) DESIGN & DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start
1	**Program Milestones**	1d	Thu 1/1/98
2	**Definitize/Start Flight Contract**	**130d**	**Thu 1/1/98**
9	Develop/Concur on E.D. w/HSD	47d	Thu 1/1/98
10	Develop/Concur on S.O.W. w/HSD	47d	Thu 1/1/98
11	Prep. Proposal based on ED/SOW	30d	Mon 3/9/98
12	Complete/Ship Proposal	1d	Mon 4/20/98
13	HSD Review /Evaluate Proposal	15d	Tue 4/21/98
14	Support Fact Finding by HSD	14d	Tue 5/12/98
15	Negotiations w/HSD	10d	Mon 6/1/98
16	Sign Contract	2d	Mon 6/15/98
17	Formal CSD	1d	Wed 7/1/98
18	**Ramp-Up Manpower (Phase-I)**	**33d**	**Thu 1/1/98**
27	Mech. Eng.	33d	Thu 1/1/98
28	Tech. Writer/Editor-CM/DM	33d	Thu 1/1/98
29	Contract/SubContract Admin./Buyer	33d	Thu 1/1/98
30	Product Assurance Eng./Mgr.	33d	Thu 1/1/98
31	PP&C (Contract)	33d	Thu 1/1/98
32	**Ramp-Up Manpower (Phase-II)**	**35d**	**Mon 6/15/98**
33	Elec. Eng. X 2	35d	Mon 6/15/98
34	Mech. Eng.	35d	Mon 6/15/98
35	Test Eng.	35d	Mon 6/15/98



Project: PCWQM PROG.; 1998 - 2001
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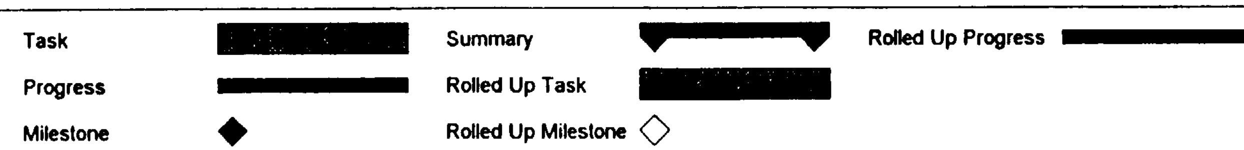
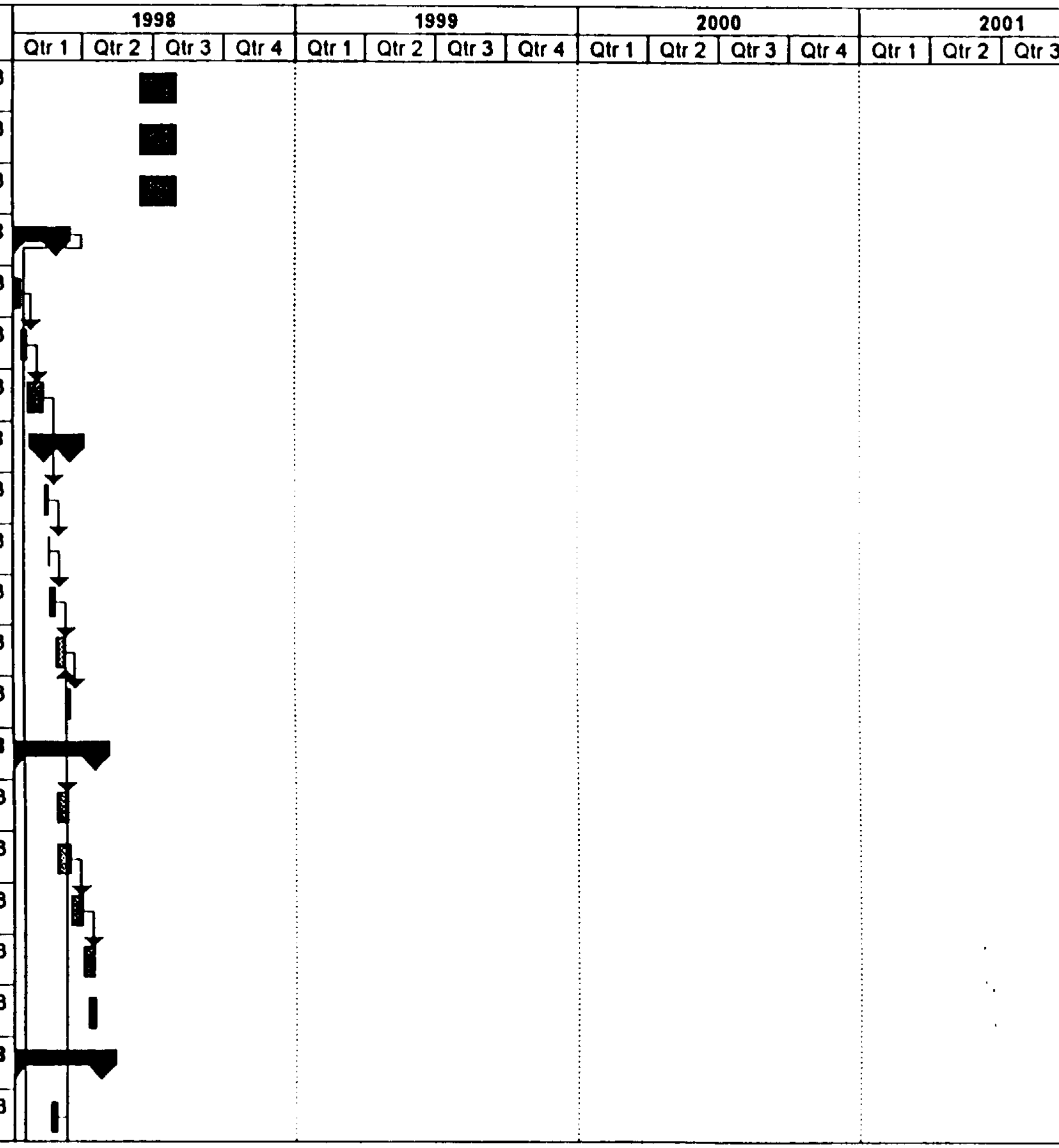


ISS PROCESS CONTROL WATER QUALITY MONITOR (PCWQM) DESIGN & DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start
36	Eng./Lab Tech. X 2	35d	Mon 6/15/98
37	SR&QA Eng.	35d	Mon 6/15/98
38	Sfw. Eng. (Contract)	35d	Mon 6/15/98
39	**Locate, Lease & Prepare Facility**	**42d**	**Thu 1/1/98**
47	Locate	8d	Thu 1/1/98
48	Lease	6d	Tue 1/13/98
49	Make Pre-Move In Facility Mods	15d	Wed 1/21/98
50	**Move Personnel & Storred Items**	**24d**	**Thu 2/12/98**
51	Move Furniture & Fixtures	4d	Thu 2/12/98
52	Move in Personnel & Setup Offices	1d	Wed 2/18/98
53	Move Archived PCWQM Documentation	6d	Thu 2/19/98
54	Move Parts & Materials	7d	Fri 2/27/98
55	Move Assy & Test Equipment	6d	Tue 3/10/98
56	**Get PCWQM Baseline under CM**	**77d**	**Thu 1/1/98**
59	Review archieved PCWQM Docc.	11d	Fri 2/27/98
60	Place latest Rev's in Active Files	12d	Fri 2/27/98
61	Verify CM baselines	11d	Tue 3/17/98
62	Update CM baseline, if Req'd	11d	Wed 4/1/98
63	Update SDD to Agreed Config.	8d	Wed 4/8/98
64	**SetUp Labs/Work Areas**	**82d**	**Thu 1/1/98**
69	Bonded Stores	6d	Thu 2/19/98

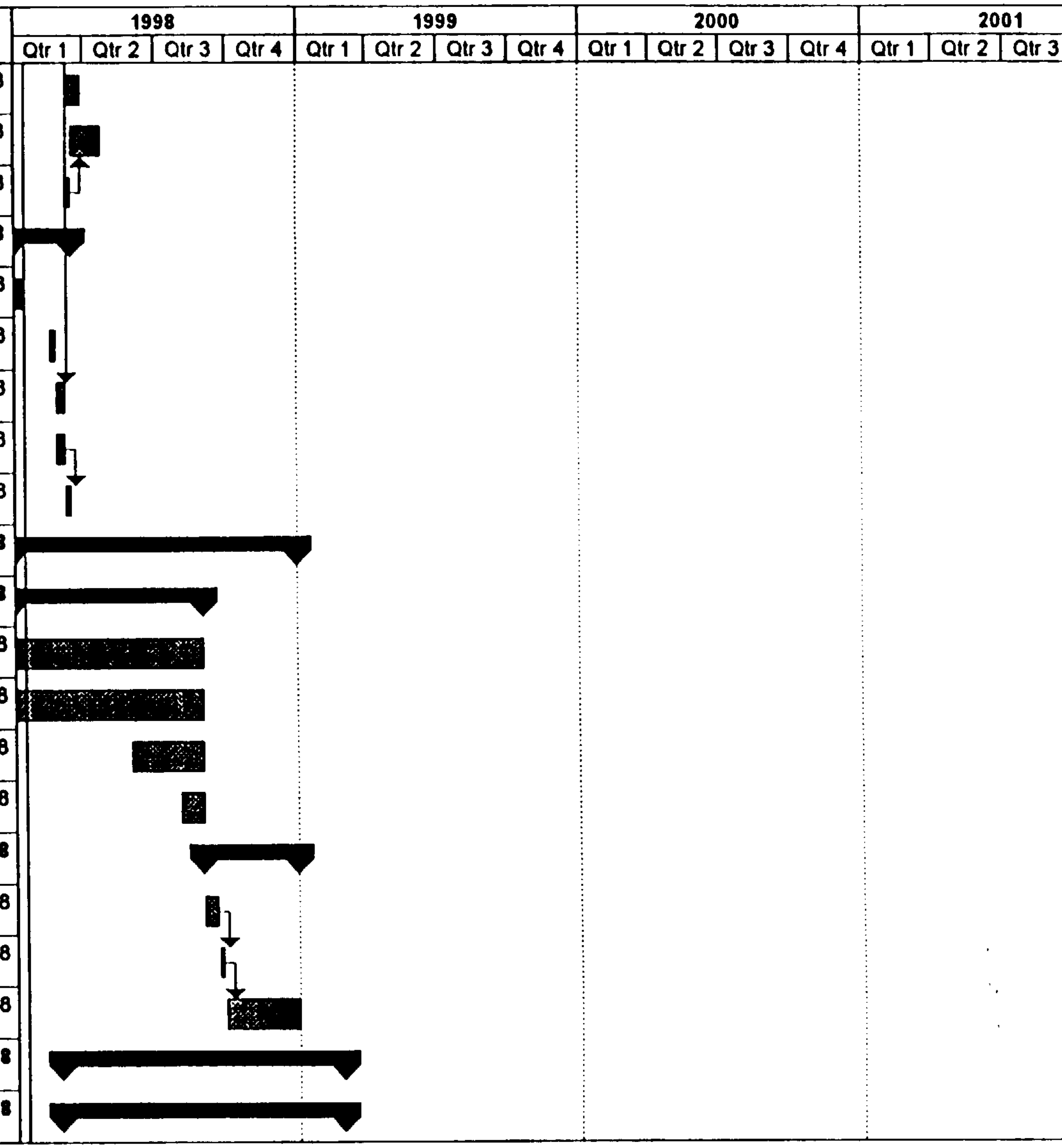


Project: PCWQM PROG.; 1998 - 2001
Date: Mon 11/17/97

Task | Summary | Rolled Up Progress
Progress | Rolled Up Task
Milestone | Rolled Up Milestone

ISS PROCESS CONTROL WATER QUALITY MONITOR (PCWQM) DESIGN & DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start
70	Wet Lab	15d	Tue 3/10/98
71	Elec. Fab & Assy. Area	28d	Wed 3/18/98
72	Test Area	6d	Tue 3/10/98
73	**Get Items Back From Boeing**	**54d**	**Thu 1/1/98**
74	Coordinate date with Boeing & NASA	11d	Thu 1/1/98
75	Receive ICSA & PCWQM Docs.	5d	Thu 2/19/98
76	Receive Parts & Materials	7d	Fri 2/27/98
77	Receive STE	7d	Fri 2/27/98
78	SetUp STE	6d	Tue 3/10/98
79	**Complete PCWQM Design Work**	**261d**	**Thu 1/1/98**
80	**Incorporate Design Mods**	**174d**	**Thu 1/1/98**
81	Update Drawings & Part Lists	174d	Thu 1/1/98
82	Other Deliverable Design Docc's.	174d	Thu 1/1/98
83	Update Test Procedures	67d	Mon 6/1/98
84	Update Mfg. Plans & Procedures	22d	Mon 8/3/98
85	**Critical Design Review (CDR)**	**88d**	**Tue 9/1/98**
86	Prepare For CDR	14d	Tue 9/1/98
87	Support CDR	5d	Mon 9/21/98
88	Resolve CDR RID's	69d	Mon 9/28/98
89	**Procure Long Lead Items**	**261d**	**Mon 3/2/98**
90	**EEE Parts**	**261d**	**Mon 3/2/98**

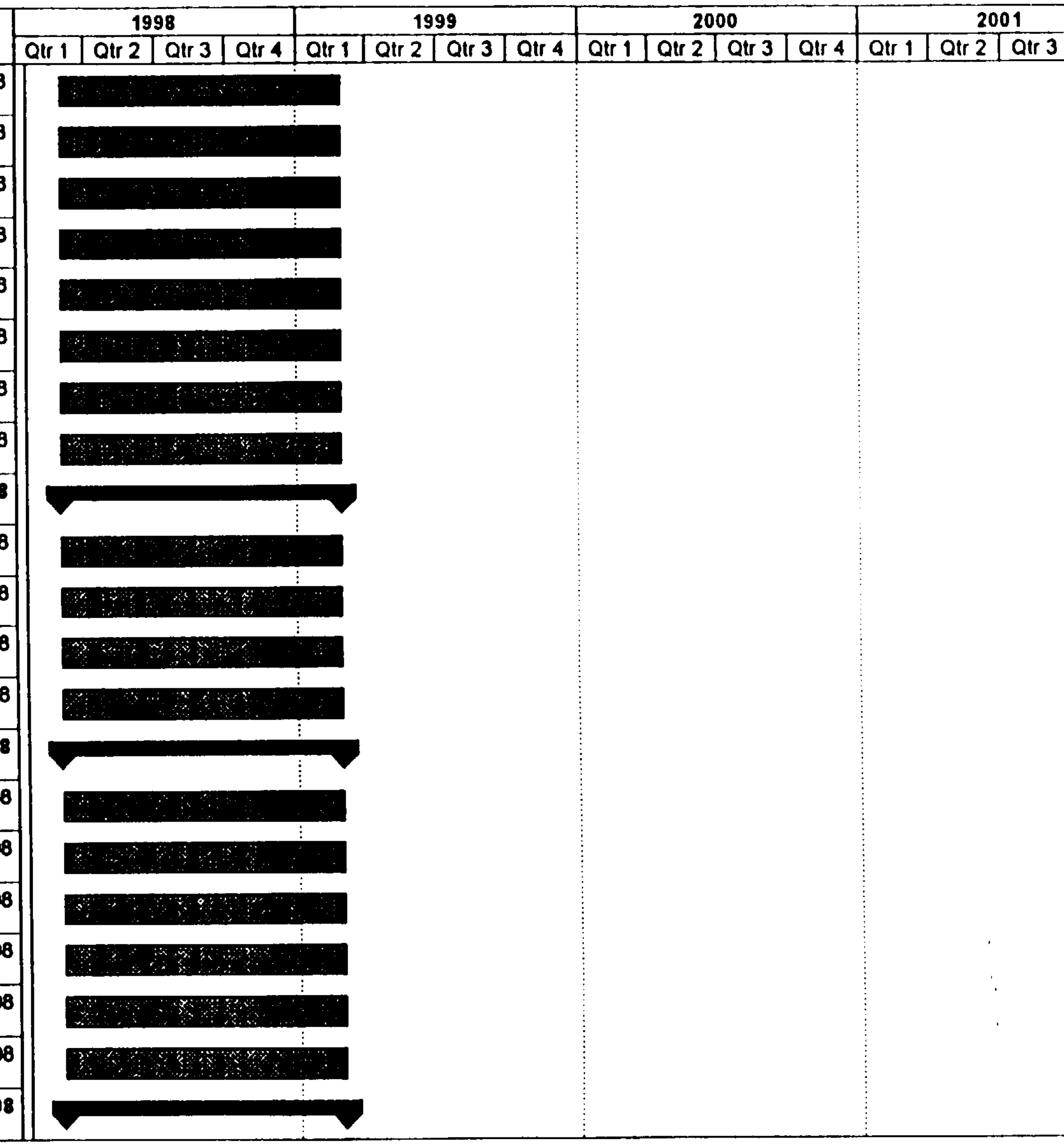


Project: PCWQM PROG.; 1998 - 2001
Date: Mon 11/17/97

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

ISS PROCESS CONTROL WATER QUALITY MONITOR (PCWQM) DESIGN & DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start
91	Blue LED's	261d	Mon 3/2/98
92	Red LED's	261d	Mon 3/2/98
93	Photodetectors	261d	Mon 3/2/98
94	IR Sources	261d	Mon 3/2/98
95	Elec. Connectors	261d	Mon 3/2/98
96	Wire	261d	Mon 3/2/98
97	I.C.'s	261d	Mon 3/2/98
98	Resistors & Capacitors	261d	Mon 3/2/98
99	**Subcontract Items**	**261d**	**Mon 3/2/98**
100	Quick Disconnects	261d	Mon 3/2/98
101	AC Synchronous Motors	261d	Mon 3/2/98
102	Stepper Motors	261d	Mon 3/2/98
103	pH Probes	261d	Mon 3/2/98
104	**Valves**	**261d**	**Mon 3/2/98**
105	2-Way	261d	Mon 3/2/98
106	3-Way	261d	Mon 3/2/98
107	Regulators	261d	Mon 3/2/98
108	Flow Restrictors	261d	Mon 3/2/98
109	Pressure Transducers	261d	Mon 3/2/98
110	Pumps	261d	Mon 3/2/98
111	**Optics**	**261d**	**Mon 3/2/98**

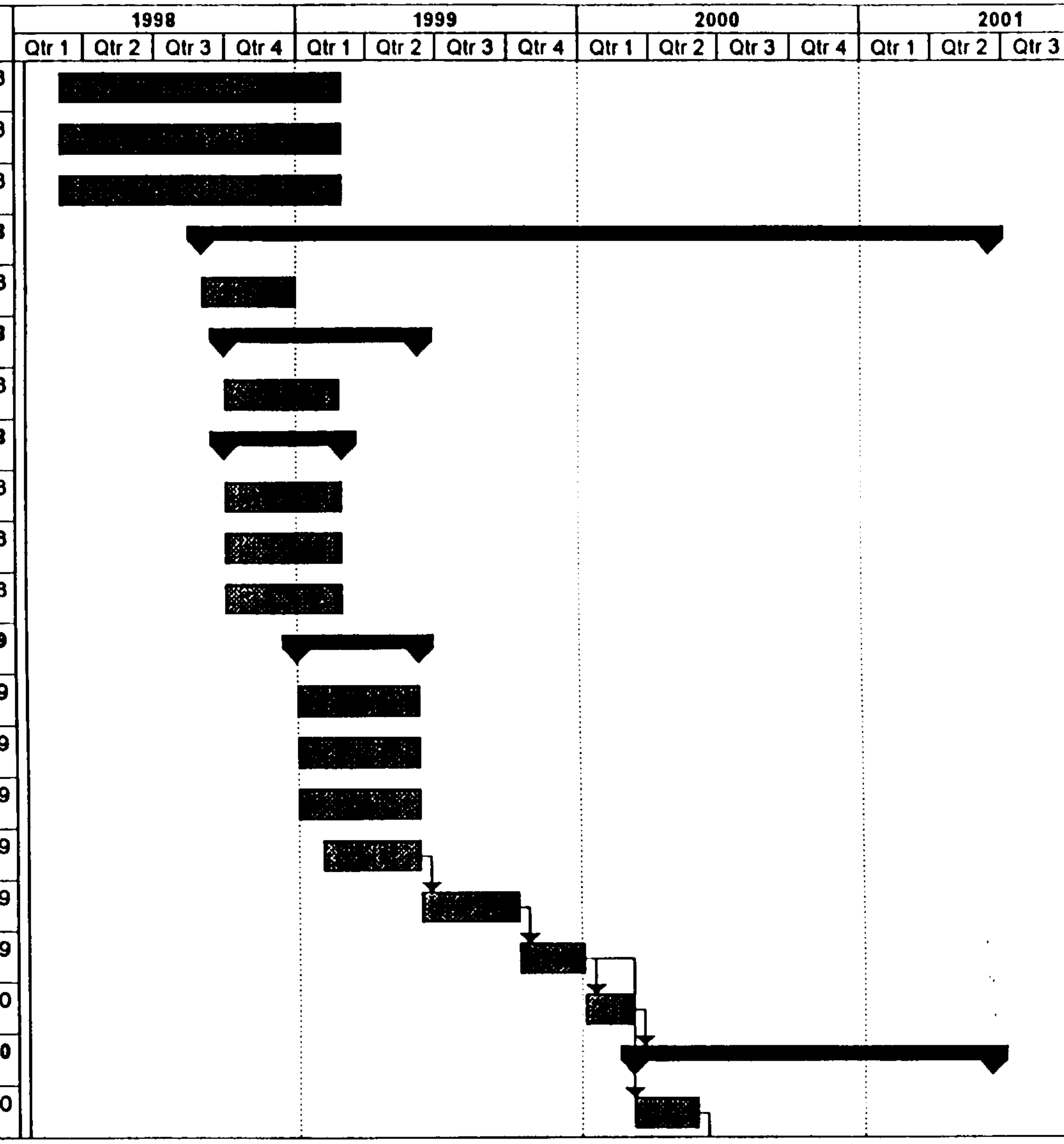


Project: PCWQM PROG.; 1998 - 2001
Date: Mon 11/17/97

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

ISS PROCESS CONTROL WATER QUALITY MONITOR (PCWQM) DESIGN & DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start
112	Beam Splitters	261d	Mon 3/2/98
113	Stepped Windows	261d	Mon 3/2/98
114	Convex Lenses	261d	Mon 3/2/98
115	**Build, Assemble, Test & Del. PCWQM**	**729d**	**Tue 9/1/98**
116	**Finalize Mfg. Plans & Procedures**	88d	Tue 9/1/98
117	**Procure Std. Parts & Materials**	**179d**	**Thu 10/1/98**
118	Materials for Fab	107d	Thu 10/1/98
119	**Subassembly Parts & Mat'ls**	**108d**	**Thu 10/1/98**
120	PCB's	108d	Thu 10/1/98
121	Mech. Fab. Parts	108d	Thu 10/1/98
122	Fastners	108d	Thu 10/1/98
123	**Top Assembly Parts & Mat'ls**	**113d**	**Fri 1/1/99**
124	PCB's	113d	Fri 1/1/99
125	Mech. Fab. Parts	113d	Fri 1/1/99
126	Fastners	113d	Fri 1/1/99
127	Fabricate Parts	92d	Mon 2/1/99
128	Assemble Subassemblies	90d	Wed 6/9/99
129	Test Subassemblies	60d	Wed 10/13/99
130	Assemble Top Assembly	45d	Wed 1/5/00
131	**Test Top assembly**	**333d**	**Wed 3/8/00**
132	Charact. & Calibration	60d	Wed 3/8/00

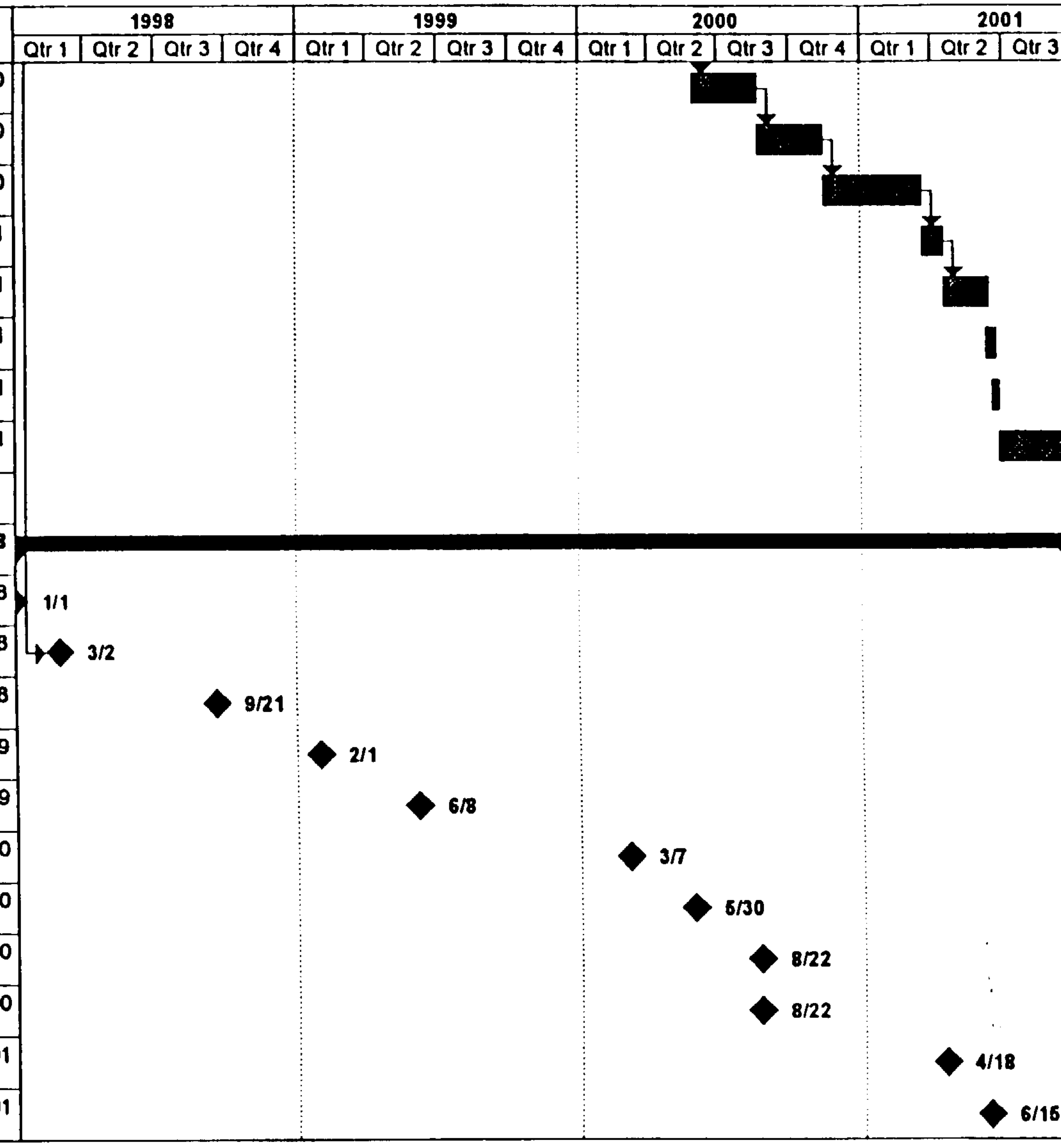


Project: PCWQM PROG.; 1998 - 2001
Date: Mon 11/17/97

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

ISS PROCESS CONTROL WATER QUALITY MONITOR (PCWQM) DESIGN & DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start
133	Functional Testing	60d	Wed 5/31/00
134	Pre-Environmental Qual Testing	60d	Wed 8/23/00
135	Environmental Qual Testing	90d	Wed 11/15/00
136	Post-Environmental Qual Testing	20d	Wed 3/21/01
137	Final ATP	43d	Wed 4/18/01
138	**Compile PCWQM & STE ADP for Ship**	10d	Tue 6/12/01
139	**Pack & Ship PCWQM, ADP & STE**	8d	Wed 6/20/01
140	Contract Closeout	66d	Fri 6/29/01
141			
142	**Major Milestones**	977d	Thu 1/1/98
143	Start Ramp Up	1d	Thu 1/1/98
144	Start Long Lead Item Procurements	1d	Mon 3/2/98
145	Critical Design Review	1d	Mon 9/21/98
146	Start Part Fab	1d	Mon 2/1/99
147	Start Subassembly build	1d	Tue 6/8/99
148	Start PCWQM Calibration	1d	Tue 3/7/00
149	Start PCWQM Funct. Testing	1d	Tue 5/30/00
150	Start Pre-Environmental Qual Testing	1d	Tue 8/22/00
151	Start Environmental Qual Testing	1d	Tue 8/22/00
152	Start Final ATP	1d	Wed 4/18/01
153	Start FCA/PCA	1d	Fri 6/15/01



Project: PCWQM PROG.; 1998 - 2001
Date: Mon 11/17/97

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

ISS PROCESS CONTROL WATER QUALITY MONITOR (PCWQM) DESIGN & DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start	1998 Qtr 1	1998 Qtr 2	1998 Qtr 3	1998 Qtr 4	1999 Qtr 1	1999 Qtr 2	1999 Qtr 3	1999 Qtr 4	2000 Qtr 1	2000 Qtr 2	2000 Qtr 3	2000 Qtr 4	2001 Qtr 1	2001 Qtr 2	2001 Qtr 3
154	Ship Hardware & ADP's	1d	Fri 6/29/01															6/29
155	Contract Closeout Complete	1d	Fri 9/28/01															

Project: PCWQM PROG.; 1998 - 2001
Date: Mon 11/17/97

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

PCWQM PROGRAM ISSUES/COST DRIVERS

What is to be delivered ?

Flight Units

Protoflight Units

Qual Units

Special Test Equipment

Spares

What requirements are to be imposed?

Space Station Full Flight, Crit 1R

Space Station Protoflight

NASA Flight Experiment

PCWQM PROGRAM ISSUES/COST DRIVERS

What is the desired delivery date/(s) ?

ASAP

Best date based on overall program cost, but not later than ____

Driven by availiability of funds

What programmatic requirements must be flowed down to subcontractors ?

Full

Partial

None

PCWQM PROGRAM ISSUES/COST DRIVERS

Will DCMO be required to perform source inspection/acceptance at subcontractor facilities?

Yes

No

To what extent will HSD QA & DCMO be involved in our assembly and test acativities?

Heavily

Minimally

PCWQM PROGRAM ISSUES/COST DRIVERS

Will Zellweger be given MRB authority?

Yes

No

Will NASA facilities be availiable to support environmental testing ? Can they be used?

JSC

MSFC

PCWQM PROGRAM ISSUES/COST DRIVERS

What EEE Part Requirements are to be imposed?

Class - "S"

MIL-883B

Best Commercial Grade

Will a detail-level Finite Element Analysis be required?

Full FEA required

Tailor based on areas of concern

Not required

PCWQM PROGRAM ISSUES/COST DRIVERS

What program reviews are to be conducted?

Delta - CDR

FCA/PCA

AR

What will the program status reporting requirements be?

Monthly cost, schedule and performance

Variance analysis, recovery plans, etc.

SDB Subcontracting

PCWQM PROGRAM ROM COST ESTIMATE

Direct Labor Hours	76752
Total Labor Cost	$1,967,282
Overhead @ 119%	$2,341,066
Direct Material	$176,876
Direct Subcontract	$1,378,987
Direct Contract Labor	$210,000
Direct Freight	$16,429
Direct Travel	$63,360
Other Direct Costs	$36,000
Total Direct Cost	$6,190,000
G&A @ 25.7%	$1,590,830
Total Cost	$7,780,829
Fixed Fee	$389,041
Total	$8,169,871

1. 36 Month Program
2. Average H.C = 12.4
3. One PCWQM delivered to Space Station Protoflight Requirements
4. Approx. $227K/mo. Funding Req'd.

PRICING FOR ION STAGE-11 PCWQM REQUEST FOR PROPOSAL

S O W PARA	S O W TASK DESCRIPTION	Prg. Mgr.	Sr. Eng.	Technician	Elec. Eng.	Tech. Pubs	Design Drafting	Mech Eng.	Machinists	TOTAL HRS.	Labor Cost	Material Cost	Sw. Eng.	PP&C	Travel Cost
		MGR	MGR	STC	ENG	ENG	DFT	SNR	MCH						
A	Evaluate & Definitize Program Requirements	200	160		60	220	8	160		808	$23,408		160	400	$3,700
B	Identify/Select Valve Suppliers	70	70				8	80		228	$7,260				
C	Conduct Packaging Analysis	80	120		40		150	180		570	$15,303				
D	Mod. CO2 Detector Source	80	120	200	120	6	60	160	200	946	$22,892	$2,521			
E	Identify/Select Supplier for UV Power Supply	40	20		16	6	8	10		100	$3,044	$5,000			
F	Identify/Select Suppliers for Other Long-Lead/Key Components									0	$0				
	AC Synchronous Motors	40	40		40	4	8	60		192	$5,540				
	Stepper Motors	40	40		30	4	7	20		141	$4,270				
	pH Probes	40	40		16	4	2	20		122	$3,879				
	Regulators	40	40			4	8	60		152	$4,664				
	Optics	40	40			6	6	40		132	$4,157				
	Pumps	40	80		20	8	8	120		276	$8,185				
	Flow Restrictors	40	40			8	8	60		156	$4,751				
	Pressure Transducers	60	80			8	8	100		256	$7,952				
	IR Sources	40	40			8	4	20		112	$3,650				
	Blue LED's	40	20			4	2	10		76	$2,547				
	Red LED's	40	20			4	2	10		76	$2,547				
	Photodetectors	40	20		20	4	6	10		100	$3,054				
G	Identify/Select Supplier for Firmware Controller Components	70	140		80	24	40	40		394	$11,578		100		
H	Identify and Coordinate Transfer of Items from ICSA Program	160	80		80	20	20	20		380	$11,717		30		
	Modify Dwg's and Associated Part Lists to Reflect Changes	160	160				240	200		760	$20,809				
	Package Refurbished/Upgraded Stage-11 PCWQM Unit for Ship	20	30					30		80	$2,581				
	Final Report	60	40					30		130	$4,387			50	
									6187						
	TOTAL LABOR HR's.	1440	1440	200	522	342	603	1440	200	6187	$178,174		290	450	
	TOTAL LABOR $$	$52,013	$52,013	$3,966	$11,437	$7,493	$10,257	$37,210	$3,786	$178,174		$7,521	$14,500	$15,750	$3,700
	MAN WK's EQUIV.	36.0	36.0	5.0	13.1	8.6	15.1	36.0	5.0	154.7			7.3	11.3	
	MAN MO's EQUIV.	9.0	9.0	1.3	3.3	2.1	3.8	9.0	1.3	38.7			1.8	2.8	
	MAN YR's EQUIV.	0.7	0.7	0.1	0.3	0.2	0.3	0.7	0.1	3.0			0.1	0.2	
	AVG /Mo. Assuming 9 Mo Project	1.0	1.0	0.1	0.4	0.2	0.4	1.0	0.1	4.30			0.2	0.3	
										4.30					

MGR	2880	$102,038.40		
SNR	1440	$37,209.60	LABOR HRS	6187
ENG	864	$18,930.24	LABOR $$	$176,187
SPL	0	$0.00	O.H. @ 119%	$209,663
DFT	603	$10,257.03	MATERIAL $$	$7,521
STC	200	$3,966.00	ODC $$$	$33,950
MCH	200	$3,786.00	G&A @ 25.7%	$109,822
TOTAL	6187	$176,187.27	FEE @ 5%	$26,857
			TOTAL	$564,000

ASSUMPTIONS RELATED TO PCWQM PROGRAM ROM COST ESTIMATE

1. Design Baseline is PCWQM-SEU Multiple ORU Configuration as submitted to Boeing in March 1995

2. Space Allocation for the PCWQM is same as for the PCWQM-SEU, plus an additional 6" in depth for Power Supply and Firmware Controller.

3. ICSA Pre-Production and ProtoFlight Units will be returned from Boeing to facilitate the ProtoFlight Iodine and Conductivity Sensors being used in the PCWQM.

4. PCWQM/ICSA STE will be returned from Boeing to support testing.

5. All PCWQM and/or ICSA Program residual equipment, hardware and spare parts will be returned from Boeing for use on this program.

6. All PCWQM and/or ICSA Program documentation and data will be returned from Boeing for use on this program.

ASSUMPTIONS RELATED TO PCWQM PROGRAM ROM COST ESTIMATE

7 Incremental EEE Part Lists and EEE Parts Applications Analysis reports will not be required. EEE Parts Lists and related analyses updates will be submitted as they are completed.

8 Full Environmental Qual (Protoflight-Levels) and ATP will be performed on Top Assembly

9 A detailed part-level Finite Element Analysis will not be required. Thermal and structural analyses will be limited to specific areas of concern.

10 Detailed incremental Mass Properties Reports will not be required. Estimates and actuals will be submitted as appropriate.

11 Software code will be written and delivered in C++

12 Individual valves will not require position indicators.

ASSUMPTIONS RELATED TO PCWQM PROGRAM ROM COST ESTIMATE

13 FDI will be limited to only that which is necessary to isolate a problem to the ORU-level.

14 Drawings, parts lists and other deliverable documents can be delivered on electronic media using industry standard formats.

15 On-orbit maintenance will be limited to ORU removal and replacement.

16 A delta-CDR will be held approx. 12 months after CSD.

17 This will be approx. a 36 month program, assuming it starts in July 1998, following a planned six-month build-up and requirements definitization period. (Duaration heavily dictated by procured item lead times and test durations)

18 Solid Phase Acidifier ORU can be replaced after 2000 hrs. (Approx. 3 mo.) of operation.

ASSUMPTIONS RELATED TO PCWQM PROGRAM ROM COST ESTIMATE

19 pH Probe ORU can be replaced after 8760 hours (approx. 12 mo.) of operation. Note: Strong possibility exists that this life limit can be extended appreciably (i.e., to 36 mo.) thru testing.

20 All PCWQM external interfaces (mechanical/structural, electrical, thermal, fluid) are clearly defined and agreed upon at a very early stage of the program.

21 Program Planning, Scheduling, and Control requirements will not dictate a full time PP&C Specialist.

22 Full Environmental Qual (Protoflight-Levels) and ATP will be performed on Top Assembly

PCWQM Program Technical History

- Boeing decided in 1991 to eliminate UV Ballast Supply, DC/DC Power Supplies, Firmware Controller, Turbidity Sensor, and Class S EEE parts from contract as a cost reduction.
- Boeing was to provide Class S EEE parts and handle integration of Astro's PCWQM-SEU to Boeing's FWC, UV Supply, DC Power Supply, and PCWQM software 3 years after PCWQM-SEU delivery.
- PCWQM-SEU presented at CDR was "single ORU" although a TIM took place in April '93 discussing multiple ORU configuration - Boeing didn't want to change baseline for CDR.

PCWQM Program Technical History

- 154 RIDs issued at CDR, one of which used to justify design change to Multiple ORU PCWQM-SEU.
- "Least number of RIDs issued to any Space Station subcontractor" . . . All closed by start of ICSA build.
- Based upon the development testing status at the time, Multiple ORU configuration became defined as follows . . .

PCWQM ORU's MANIFOLD ASSEMBLIES

ORU Number	Orbital Replacement Unit (ORU) Description
1	PCWQM Top Assembly, Less ORU - 2 and ORU - 3 (3 to 5 Year Life)
2	Heated Solid Phase Acidifier (SPA) Module (90 Day Life @ 42% Duty Cycle)
3	SPA #2, pH Assembly, and Valves (>1 Year Life)

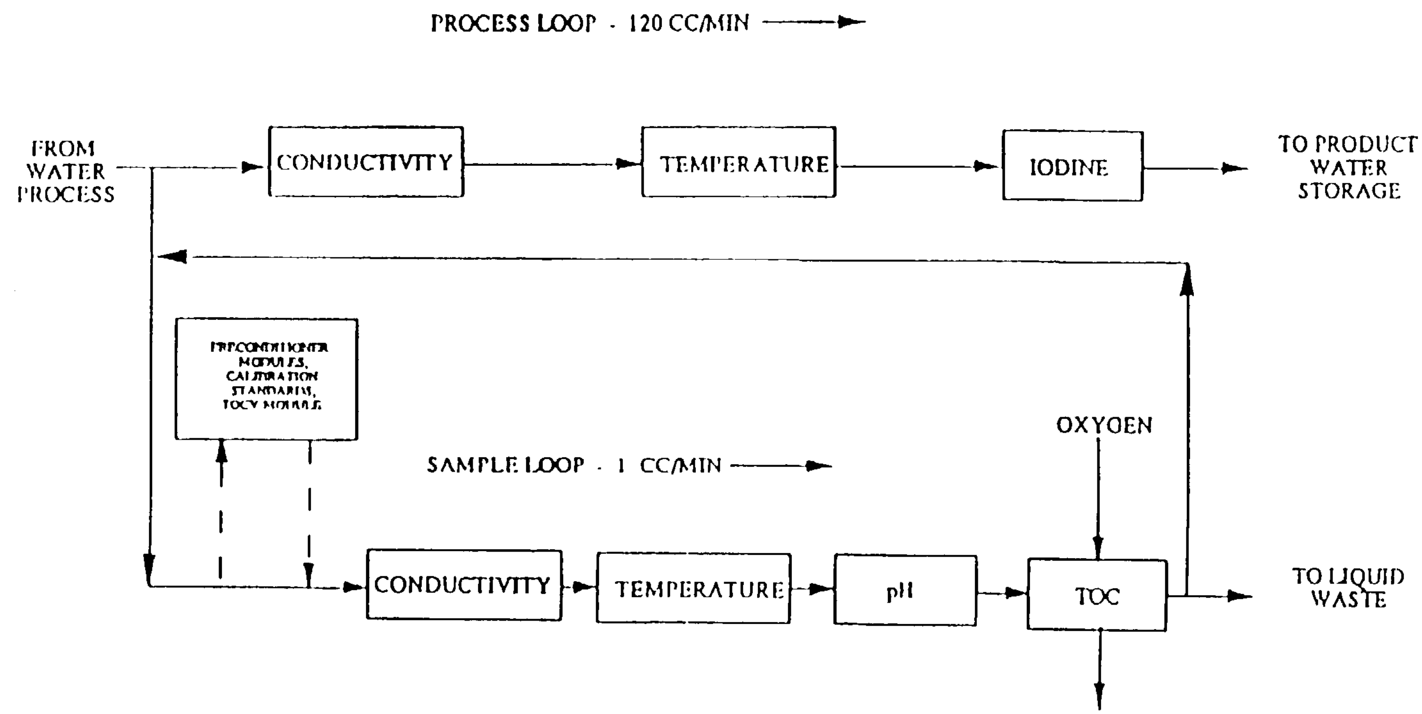
Manifold Number	Manifold Description
1	ORU Interface Manifold (Connects ORU - 3 to mainframe)
2	ORU - 3 Manifold (Connects ORU - 2 to ORU - 3)
3	ORU - 2 Manifold (Piece Part Detail of ORU - 2)
4	UV Reactor Interface Manifold (Ties to UV Reactor, Cold Plate, & Mounting Plate)
5	Oxygen Manifold (Oxygen Gas Loop)
6	Sample Out Manifold (Ties Waste Out to QD - 4)
7	Recirculation Manifold (Sample Loop Inlet Valve)

ASTRO

BOEING

SYSTEM LEVEL DESIGN

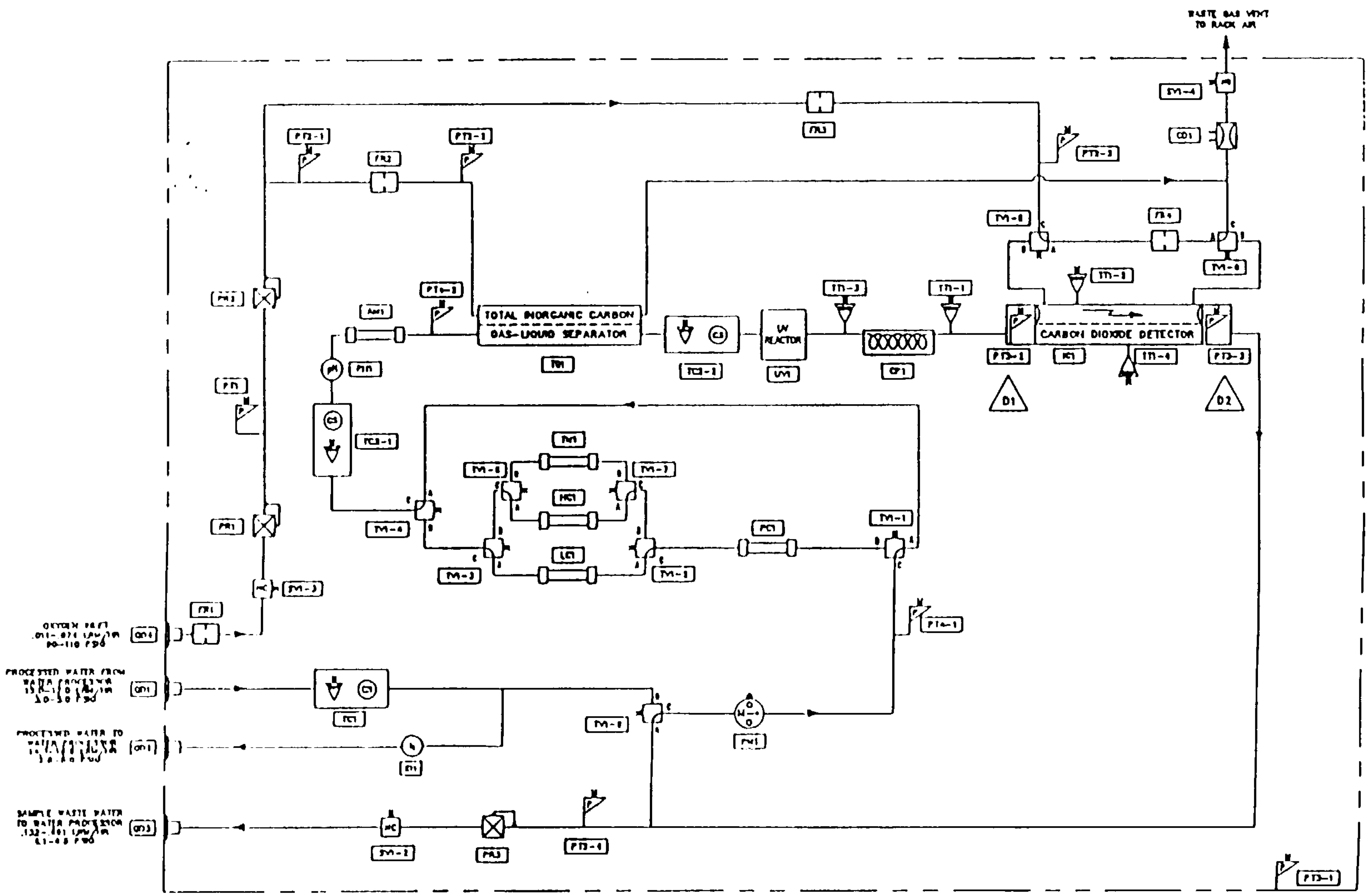
PCWQM-SEU BLOCK DIAGRAM



BOEING

SYSTEM LEVEL DESIGN

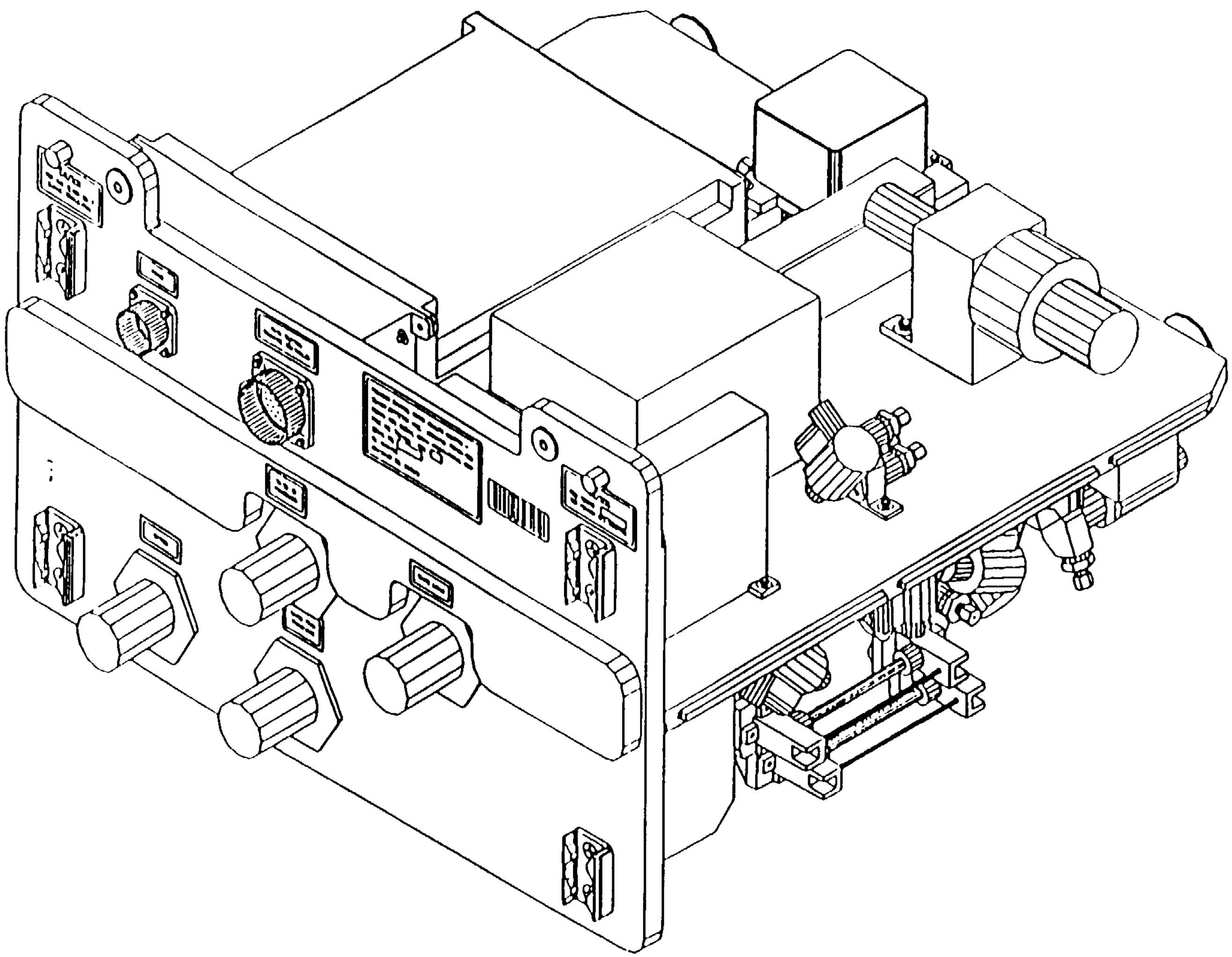
PCWQM-SEU FLOW DIAGRAM



BOEING

SYSTEM LEVEL DESIGN

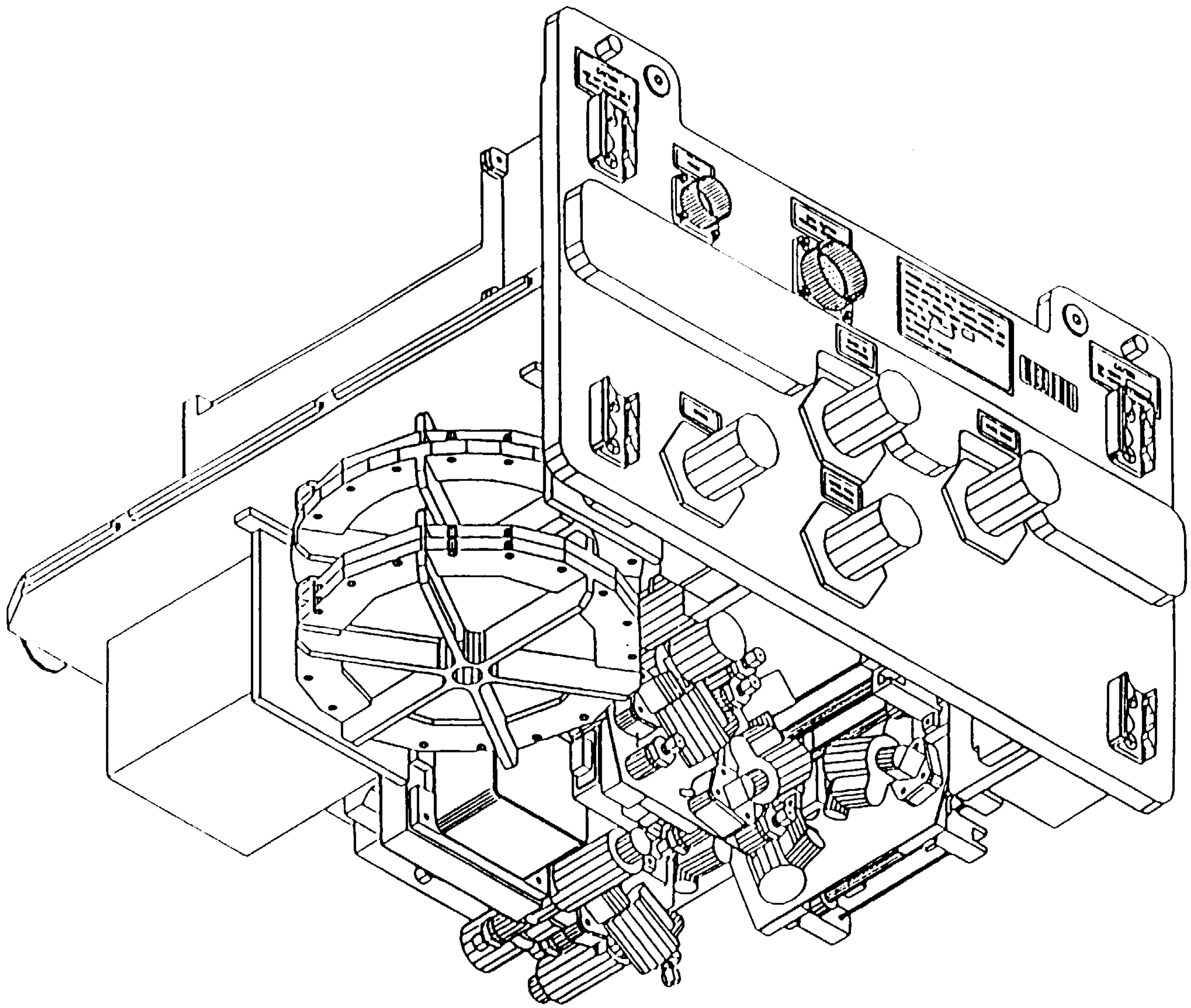
PCWQM-SEU TOP VIEW



BOEING

SYSTEM LEVEL DESIGN

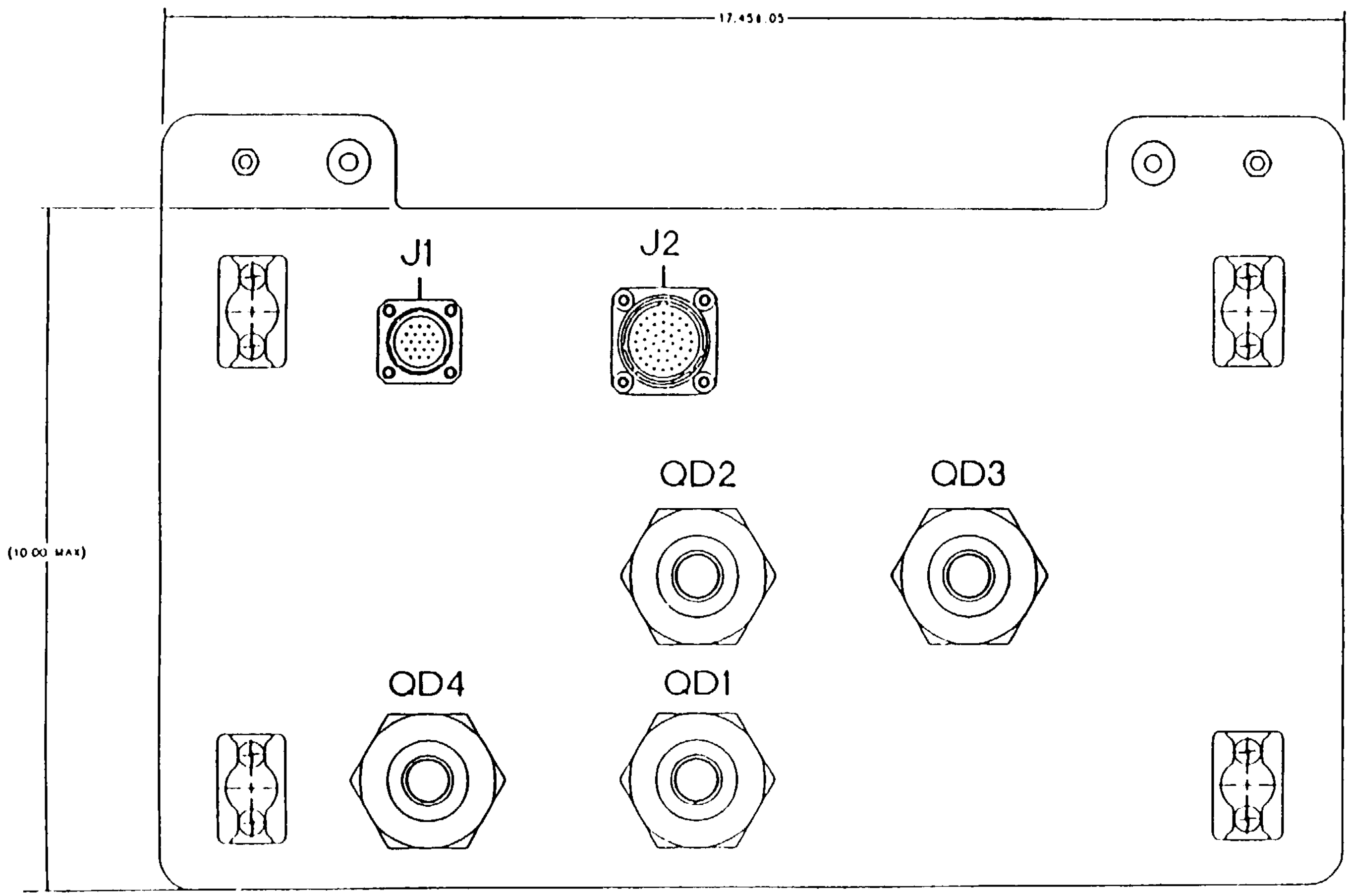
PCWQM-SEU BOTTOM VIEW



BOEING

SYSTEM LEVEL DESIGN

MECHANICAL INTERFACES



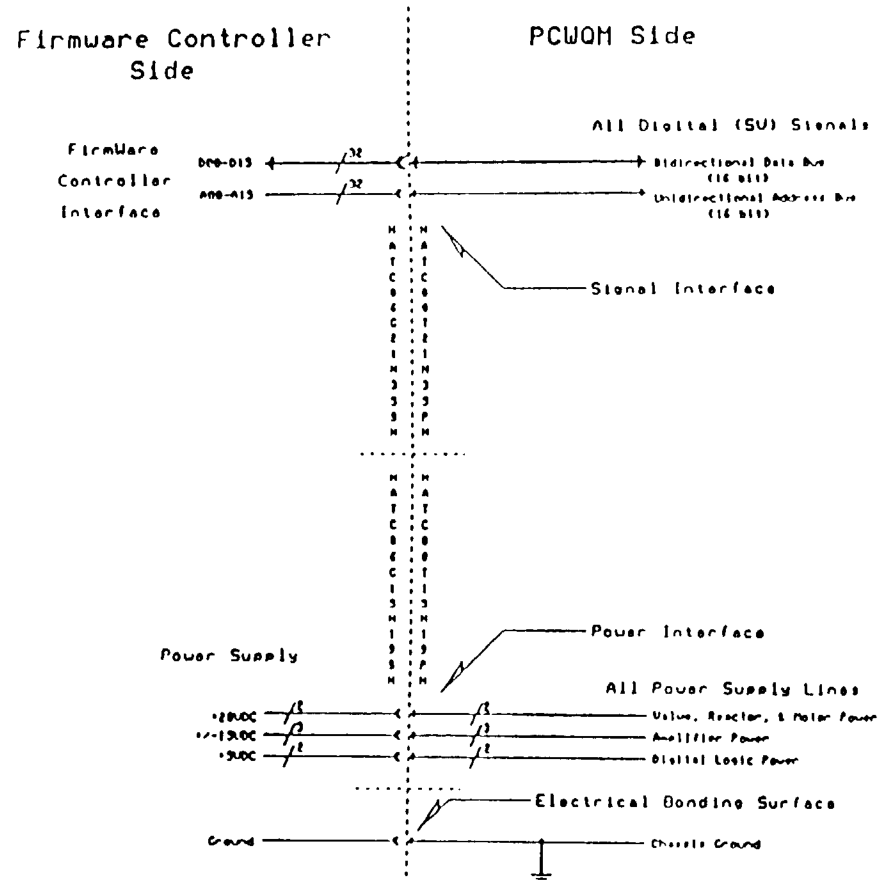
FRONT VIEW

DWG #7330036, REV. D

BOEING

ELECTRICAL INTERFACES

ELECTRICAL INTERCONNECT
PCWQM-SEU ORU ELECTRICAL INTERFACE



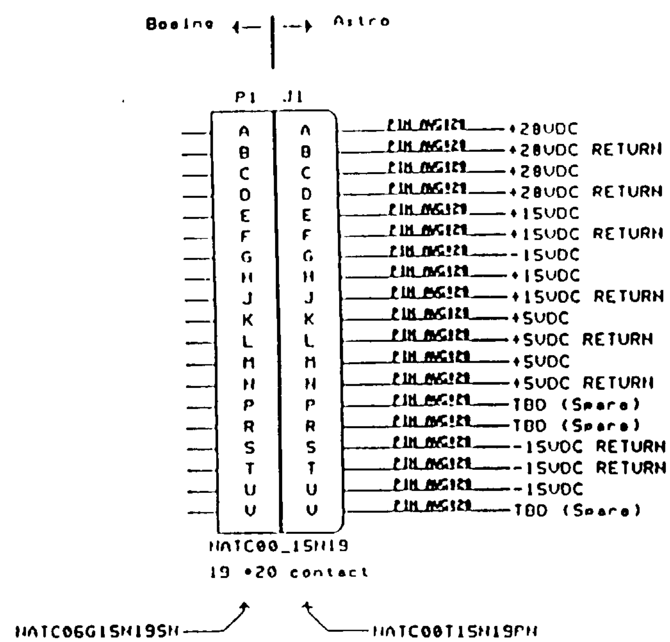
PCWQM Power & Signal Interface

DWG #7330035, REV. C

BOEING

ELECTRICAL INTERFACES

ELECTRICAL INTERCONNECT
ELECTRICAL POWER CONNECTOR



Power Connector I/F

NOTES:

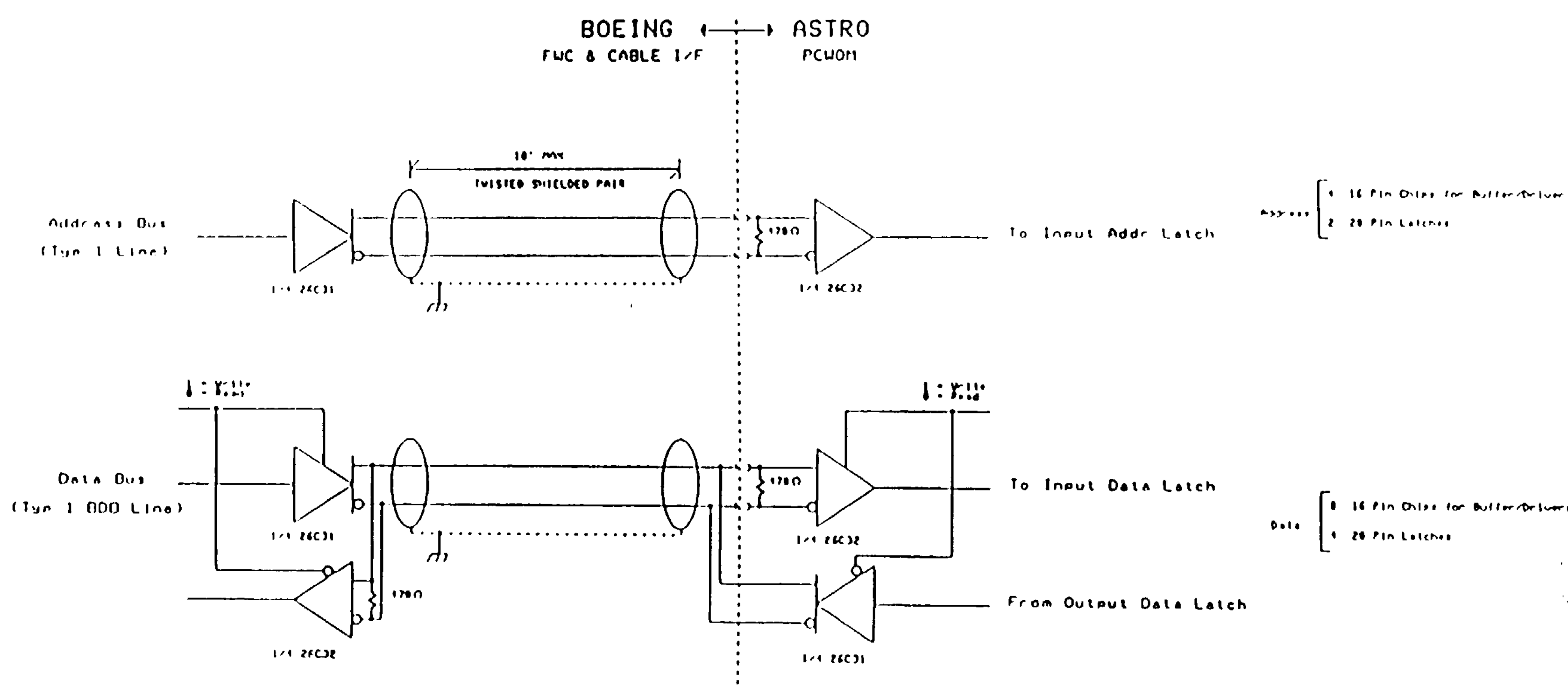
1. Pins [illegible] in Power Connector are unconnected
2. All pins without a connection will be Installed

DWG #7330035, REV. C

BOEING

ELECTRICAL INTERFACES

ELECTRICAL INTERCONNECT
PCWQM-SEU BUS INTERFACE



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BOEING

ELECTRICAL INTERFACES

ELECTRICAL INTERCONNECT SIGNAL CONNECTOR INTERFACE

DWG #7330035, REV. C

Boeing ← | → Astro

Twisted shielded pairs

P2	J2	Signal	
1	1	ICP_AMUX_Addr1 +	A00+
2	2	ICP_AMUX_Addr1 -	A00-
3	3	ICP_AMUX_Addr2 +	A01+
4	4	ICP_AMUX_Addr2 -	A01-
5	5	ICP_AMUX_Addr3 +	A02+
6	6	ICP_AMUX_Addr3 -	A02-
7	7	Sens_AMUX_Addr1 +	A03+
8	8	Sens_AMUX_Addr1 -	A03-
9	9	Sens_AMUX_Addr2 +	A04+
10	10	Sens_AMUX_Addr2 -	A04-
11	11	Sens_AMUX_Addr3 +	A05+
12	12	Sens_AMUX_Addr3 -	A05-
13	13	Cntrl LE 1 +	A06+
14	14	Cntrl LE 1 -	A06-
15	15	Cntrl LE 2 +	A07+
16	16	Cntrl LE 2 -	A07-
17	17	Cntrl LE 3 +	A08+
18	18	Cntrl LE 3 -	A08-
19	19	ADC Start +	A09+
20	20	ADC Start -	A09-
21	21	ADC Read +	A10+
22	22	ADC Read -	A10-
23	23	NVRAM Enable +	A11+
24	24	NVRAM Enable -	A11-
25	25	Space Addr1 +	A12+
26	26	Space Addr1 -	A12-
27	27	Space Addr2 +	A13+
28	28	Space Addr2 -	A13-
29	29	Space Addr3 +	A14+
30	30	Space Addr3 -	A14-
31	31	Space Addr4 +	A15+
32	32	Space Addr4 -	A15-
33	33	BiData00 (LSB) +	D00+
34	34	BiData00 (LSB) -	D00-
35	35	BiData01 +	D01+
36	36	BiData01 -	D01-
37	37	BiData02 +	D02+
38	38	BiData02 -	D02-
39	39	BiData03 +	D03+
40	40	BiData03 -	D03-

P2	J2	Signal	
41	41	BiData04 +	D04+
42	42	BiData04 -	D04-
43	43	BiData05 +	D05+
44	44	BiData05 -	D05-
45	45	BiData06 +	D06+
46	46	BiData06 -	D06-
47	47	BiData07 +	D07+
48	48	BiData07 -	D07-
49	49	BiData08 +	D08+
50	50	BiData08 -	D08-
51	51	BiData09 +	D09+
52	52	BiData09 -	D09-
53	53	BiData10 +	D10+
54	54	BiData10 -	D10-
55	55	BiData11 +	D11+
56	56	BiData11 -	D11-
57	57	BiData12 +	D12+
58	58	BiData12 -	D12-
59	59	BiData13 +	D13+
60	60	BiData13 -	D13-
61	61	BiData14 +	D14+
62	62	BiData14 -	D14-
63	63	BiData15 (MSB) +	D15+
64	64	BiData15 (MSB) -	D15-
65	65		TBD (Spare)
66	66		TBD (Spare)
67	67	Signal Gnd	SG
68	68	Signal Gnd	SG
69	69	Signal Gnd	SG
70	70	Signal Gnd	SG
71	71		TBD (Spare)
72	72		TBD (Spare)
73	73		TBD (Spare)
74	74		TBD (Spare)
75	75		TBD (Spare)
76	76		TBD (Spare)
77	77		TBD (Spare)
78	78		TBD (Spare)
79	79		TBD (Spare)

NATCO__21N35
79#22D contacts

NATC06G21N35SN
NATC00T21N35PN

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ELECTRICAL INTERFACE

ADDRESS TABLE
(ELECTRICAL HW ⇔ SW INTERFACE)

Address Bus Selection Word											Description		Data Bus Control/Status/Data Word																Comments
A15	A14	A13	A12	A11	A10 A5	A4	A3	A2	A1	A0	SENSORS	FUNCTION	DS15	DS14	DS13	DS12	DS11	DS10	DS9	DS8	DS7	DS6	DS5	DS4	DS3	DS2	DS1	DS0	
1	0	0	0	1->0	x	0	0	0	0	0	TEMP_SEL_TC1	WRITE TEMP CHANNEL (0,0)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	0	0	0	0	TEMP_IN_TC1	READ TEMP A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TC1 data output
1	0	0	0	1->0	x	0	0	0	1	0	TEMP_SEL_TC2-1	WRITE TEMP CHANNEL (0,2)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	0	0	1	0	TEMP_IN_TC2-1	READ TEMP A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TC2-1 data output
1	0	0	0	1->0	x	0	0	1	0	0	TEMP_SEL_TC2-2	WRITE TEMP CHANNEL (0,4)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	0	1	0	0	TEMP_IN_TC2-2	READ TEMP A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TC2-2 data output
1	0	0	0	1->0	x	0	1	0	1	0	IGI_TEMP1_SEL	WRITE TEMP CHANNEL (1,2)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	1	0	1	0	IGI_TEMP1_IN	READ TEMP A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TEMP1 data output
1	0	0	0	1->0	x	0	1	0	1	1	IGI_TEMP2_SEL	WRITE TEMP CHANNEL (1,3)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	1	0	1	1	IGI_TEMP2_IN	READ TEMP A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TEMP2 data output
1	0	0	0	1->0	x	0	1	1	0	0	IGI_TEMP3_SEL	WRITE TEMP CHANNEL (1,4)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	1	1	0	0	IGI_TEMP3_IN	READ TEMP A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TEMP3 data output
1	0	0	0	1->0	x	0	1	1	0	1	IGI_TEMP4_SEL	WRITE TEMP CHANNEL (1,5)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	1	1	0	1	IGI_TEMP4_IN	READ TEMP A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TEMP4 data output
1	0	0	0	1->0	x	0	0	0	0	1	COND_SEL_TC1	WRITE COND CHANNEL (0,1)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	0	0	0	1	COND_IN_TC1	READ COND A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TC1 data output
1	0	0	0	1->0	x	0	0	0	1	1	COND_SEL_TC2-1	WRITE COND CHANNEL (0,3)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	0	0	1	1	COND_IN_TC2-1	READ COND A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TC2-1 data output
1	0	0	0	1->0	x	0	0	1	0	1	COND_SEL_TC2-2	WRITE COND CHANNEL (0,5)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	0	0	1	0	1	COND_IN_TC2-2	READ COND A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted TC2-2 data output
1	0	0	0	1->0	x	1	0	0	0	0	PT1_SEL	WRITE PRESSURE CHAN (2,0)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	1	0	0	0	0	PT1_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT1 data output
1	0	0	0	1->0	x	1	0	0	0	1	PT2-1_SEL	WRITE PRESSURE CHAN (2,1)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	1	0	0	0	1	PT2-1_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT2-1 data output
1	0	0	0	1->0	x	1	0	0	1	0	PT2-2_SEL	WRITE PRESSURE CHAN (2,2)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	1	0	0	1	0	PT2-2_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT2-2 data output
1	0	0	0	1->0	x	1	0	0	1	1	PT2-3_SEL	WRITE PRESSURE CHAN (2,3)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	1	0	0	1	1	PT2-3_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT2-3 data output
1	0	0	0	1->0	x	1	0	1	0	0	PT2-4_SEL	WRITE PRESSURE CHAN (2,4)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	1	0	1	0	0	PT2-4_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT2-4 data output
1	0	0	0	1->0	x	1	0	1	0	1	PT3-1_SEL	WRITE PRESSURE CHAN (2,5)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	1	0	1	0	1	PT3-1_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT3-1 data output
1	0	0	0	1->0	x	1	0	1	1	0	PT3-2_SEL	WRITE PRESSURE CHAN (2,6)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1->0	x	1	0	1	1	0	PT3-2_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT3-2 data output

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ELECTRICAL INTERFACE

ADDRESS TABLE
(ELECTRICAL HW ⇔ SW INTERFACE)

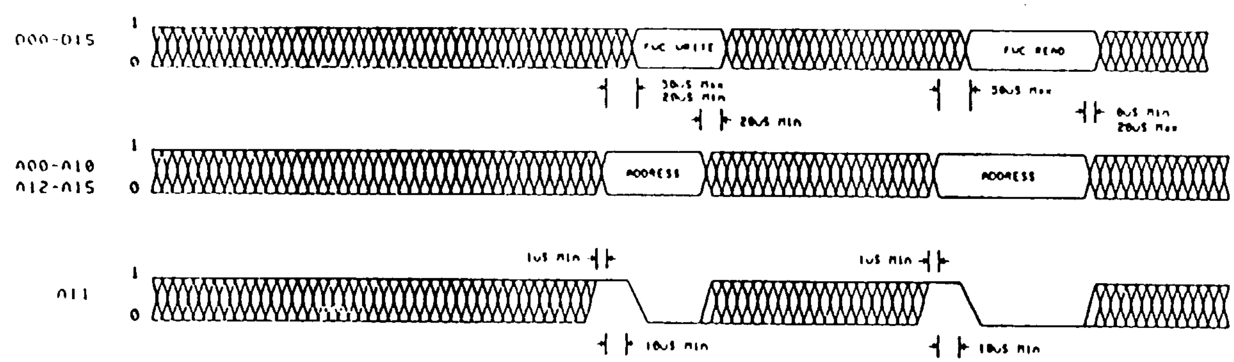
Address Bus Selection Word											Description		Data Bus Control/Status/Data Word																Comments
A15	A14	A13	A12	A11	A10 A5	A4	A3	A2	A1	A0	SENSORS	FUNCTION	DS15	DS14	DS13	DS12	DS11	DS10	DS9	DS8	DS7	DS6	DS5	DS4	DS3	DS2	DS1	DS0	
1	0	0	0	1→0	x	1	0	1	1	1	PT3-3_SEL	WRITE PRESSURE CHAN (1,7)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1→0	x	1	0	1	1	1	PT3-3_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT3-3 data output
1	0	0	0	1→0	x	1	1	0	0	0	PT4-1_SEL	WRITE PRESSURE CHAN (1,0)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1→0	x	1	1	0	0	0	PT4-1_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT4-1 data output
1	0	0	0	1→0	x	1	1	0	0	1	PT4-2_SEL	WRITE PRESSURE CHAN (1,1)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1→0	x	1	1	0	0	1	PT4-2_IN	READ PRESSURE A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted PT4-2 data output
1	0	0	0	1→0	x	0	0	1	1	0	PH1_SIO_SEL	WRITE pH CHANNEL (0,6)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1→0	x	0	0	1	1	0	PH1_SIO_IN	READ pH A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted pH data output
1	0	0	0	1→0	x	0	0	1	1	1	IDI_INCI_SEL	WRITE IODINE INCI CHAN (0,7)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1→0	x	0	0	1	1	1	IDI_INCI_IN	READ IODINE INCI A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted I2 incident data output
1	0	0	0	1→0	x	0	1	0	0	0	IDI_TRAN_SEL	WRITE IODINE TRAN CHAN (1,0)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1→0	x	0	1	0	0	0	IDI_TRAN_IN	READ IODINE TRAN A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted I2 transmitted data output
1	0	0	0	1→0	x	0	1	0	0	1	IGI_SIG_SEL	WRITE TOC CHANNEL (1,1)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects mux; no control needed
0	0	0	0	1→0	x	0	1	0	0	1	IGI_SIO_IN	READ TOC A/D DATA	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	Address prompts A/D & puts on data bus, converted IR detector data output
0	0	0	1	A	AAAAAA	A	A	A	A	1	READ LOBYTE	NVRAM ENABLE - READ LO B	x	x	x	x	x	x	x	x	D	D	D	D	D	D	D	D	Address selects NOVRAM memory address; memory provides lower byte of data constant
0	0	0	1	A	AAAAAA	A	A	A	A	0	READ HIBYTE	NVRAM ENABLE - READ HI B	x	x	x	x	x	x	x	x	D	D	D	D	D	D	D	D	Address selects NOVRAM memory address, memory provides upper byte of data constant
x	x	x	x	A	AAAAAA	A	A	A	A	1	WRITE LOBYTE	NVRAM ENABLE - WRITE LO B	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects NOVRAM memory address; write cycle not applicable on orbit
x	x	x	x	A	AAAAAA	A	A	A	A	0	WRITE HIBYTE	NVRAM ENABLE - WRITE HI B	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects NOVRAM memory address, write cycle not applicable on orbit
1	0	1	0	1→0	x	x	x	x	0	1	NORMAL (1ml)	METER PUMP	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects pump on @ 1ml/min, no control needed
1	0	1	0	1→0	x	x	x	x	0	0	HI (3ml)	METER PUMP	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects pump on @ 3 ml/min, no control needed
1	0	1	0	1→0	x	x	x	x	1	x	PUMP OFF	METER PUMP	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Address selects turns pump off, no control needed
0	0	1	1	1→0	x	x	x	x	x	0	BIT 0-15	READ DIGITAL I/O	TVI-3_C	TVI-3_O	TVI-4_C	TVI-4_O	TVI-3_C	TVI-3_O	TVI-2_C	TVI-3_O	TVI-1_C	TVI-1_O	SVI-4_C	SVI-4_O	SVI-3_C	SVI-3_O	SVI-3_C	SVI-3_O	Address selects Low Word Status, 1=not, 0=sensed
0	0	1	1	1→0	x	x	x	x	x	1	BIT 16-31	(Bit Data values, uv, i2, od)	NC	NC	CDI_SIO	UV_V OK	UV_I OK	IDI_TRIG	IDI_MSY NC	IGI_INT	TVI-9_C	TVI-9_O	TVI-8_C	TVI-8_O	TVI-7_C	TVI-7_O	TVI-6_C	TVI-6_O	Address selects High Word Status, 1=not, 0=sensed
1	0	1	1	1→0	x	x	x	x	x	0	BIT 0-15	WRITE DIGITAL I/O	IGI_ST	x	TC_RIT	CDI_EN	SVI-4_EN	SVI-3_EN	SVI-2_EN	TVI-9_EN	TVI-8_EN	TVI-7_EN	TVI-6_EN	TVI-5_EN	TVI-4_EN	TVI-3_EN	TVI-2_EN	TVI-1_EN	Address selects Low Word Control, 0=enabled, 1=not enabled
1	0	1	1	1→0	x	x	x	x	x	1	BIT 16-31	(Bit data values, UV, I2, sol, od)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	x	AH_EN	DF_EN	UV_EN	IDI_EN	Address selects High Word Control, 0=enabled, 1=not enabled
0	1	1	1	1→0	x	x	x	x	x	x	A/D_INIT	SYSTEM RESET, INITIALIZE	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Resets and reinitializes the SIPEX A/D hybrid

(n,m) mux n, channel
T tristate bit
A address bit
x don't care
1→0 hi to low transition
NC Not Connected
D A/D Converted Data Available

BOEING

ELECTRICAL INTERFACES

ELECTRICAL INTERCONNECT
TIMING DIAGRAM & SOFTWARE INTERFACE



DWG #7330035, REV. C

SYSTEM LEVEL DESIGN

DEVELOPMENT TESTING COMPLIANCE

UNIT	REQUIRED/DERIVED ACCURACY	TEST TYPE	MEASURED ACCURACY TO DATE	SCHEDULED TEST DATE DOCUMENT NUMBER
pH	± 0.5	Formal	< ± 0.36 pH	Complete, see AIC-SS-1202
MOTOR PUMP	± 0.01 ml/min (derived)	Formal	± 0.01 ml/min	Complete, see AIC-SS-1167
1/4 INCH TEMPERATURE	± 1.0 °F	Formal	± 0.36 °F	Complete, see AIC-SS-1220
1/4 INCH CONDUCTIVITY	± 1.0 μS/cm	Formal	± 0.25 μS/cm	Complete, see AIC-SS-1220
IODINE	± 0.2 mg/l	Formal	± 0.10 mg/l	Complete, see AIC-SS-1253
CO_2 DETECTOR	± 10 ppm CO_2 (derived)	Formal	± 8 ppm CO_2	In process, see AIC-SS-1258
UV REACTOR	Oxidation ≥ 90% with a <2 mg C/l sample (derived)	Formal	95%	In process, see AIC-SS-1258
TIC/GLS	Residual < 30 μg/l with a 5 mg C/l sample (derived)	Formal	<20 μg/l	In process, see AIC-SS-1258
0.04 INCH TEMPERATURE	± 2.5 °F (derived)	Formal	0.36 °F by similarity	Complete, see AIC-SS-1220
0.04 INCH CONDUCTIVITY	± 10.0 μS/cm (derived)	Formal	< ± 7.9 μS/cm	Complete, see AIC-SS-1241
HIGH CALIBRATION MODULE	± 0.1 pH units over operational life	Formal	± 0.25 pH units over operational life	Complete, see AIC-SS-1265
LOW CALIBRATION MODULE	± 0.1 pH units over operational life	Formal	± 0.1 pH units over operational life	Complete, see AIC-SS-1265
SOLID PHASE ACIDIFIER	pH < 4.0 for 2,880 hours (211.1 liters)	Formal	> 25 liters	In process, see AIC-SS-1284
TOCV MODULE	± 50 μg C/l over operational life	Formal		December 1993

BOEING

PROCESS LOOP TEMP./CONDUCTIVITY SENSOR

REQUIREMENTS

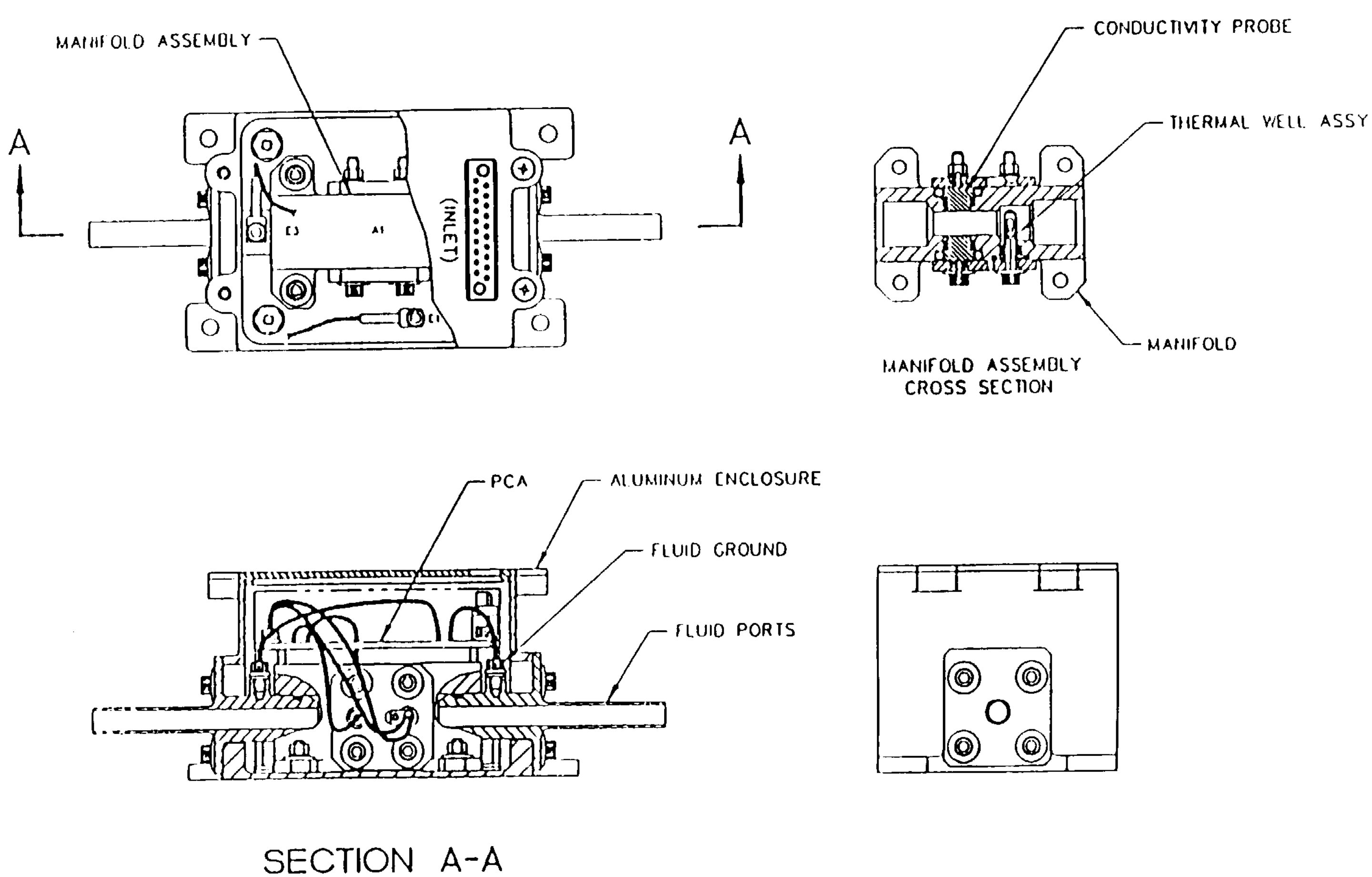
The process loop temperature/conductivity sensor design results in the following derived functional requirements:

- Conductivity measuring range = 1 - 30 μS/cm compensated to 25 °C using standard solution SRM 3190 as a reference
- Conductivity sensitivity/tolerance = ± 1.0 μS/cm
- Temperature measuring range = 50 - 150 °F
- Temperature sensitivity/tolerance = ± 1.0 °F (± 0.56 °C)
- Operating flow rate = 15 - 17 lb/hr (100-130 ml/min)
- Supplied water shall be gas free

BOEING

PROCESS LOOP TEMP./CONDUCTIVITY SENSOR

DESIGN



IODINE DETECTOR

REQUIREMENTS

The PCWQM-SEU requires iodine measurement with the following specifications:

- Iodine measuring range = 0.1 - 6.0 mg/l
- Iodine sensitivity/tolerance = ± 0.2 mg/l at iodine-iodide equilibrium in pure water and constant pH for accuracy during process
- Operating temperature range = 50 - 150 °F
- Operating flow rate = 15 - 17 lb/hr (100-130 ml/min)
- Supplied water shall be gas free
- Operating pH range = 5 - 9 pH units

IODINE DETECTOR

REQUIREMENTS

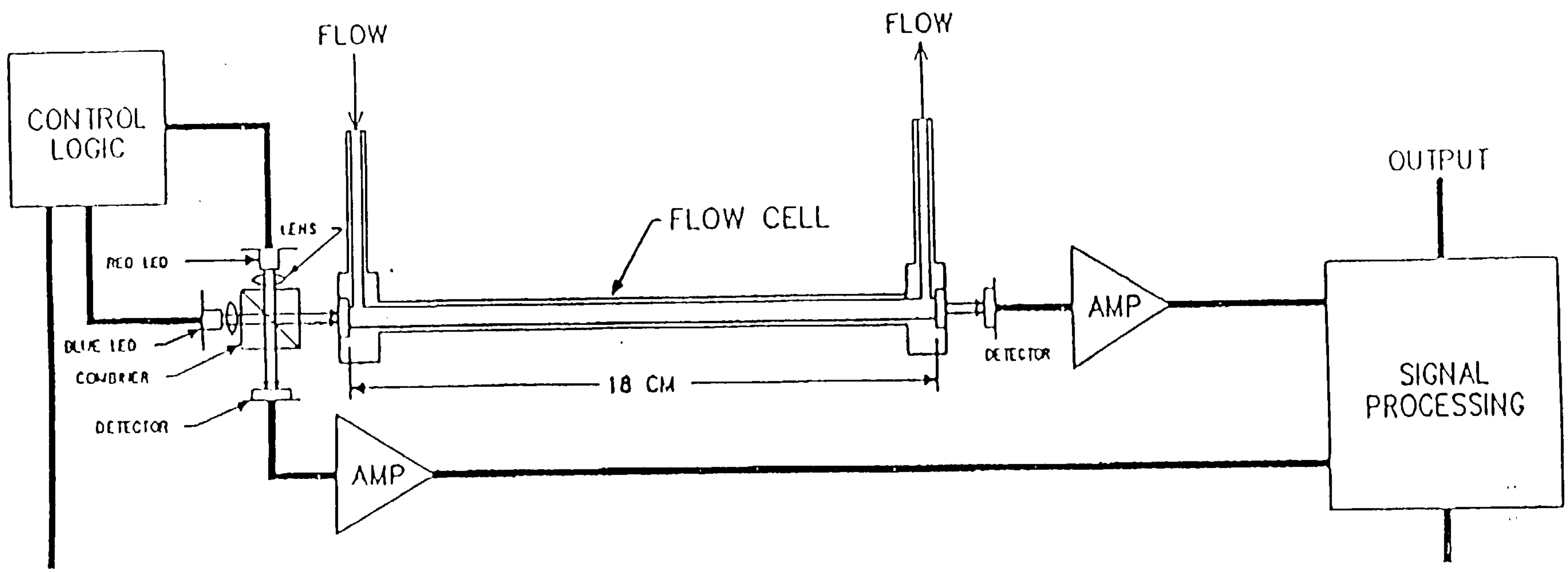
The iodine detector design results in the following derived functional requirements:

- Optical path length $\leq$ 18 cm

BOEING

IODINE DETECTOR

IODINE DETECTOR BLOCK DIAGRAM



BOEING

pH MEASURING SUBSYSTEM

REQUIREMENTS

The PCWQM-SEU requires pH measurement with the following specifications:

- pH measuring range = 5 - 9 pH units
- pH sensitivity/tolerance = ± 0.5 pH units
- Operating temperature range = 50 - 150 °F

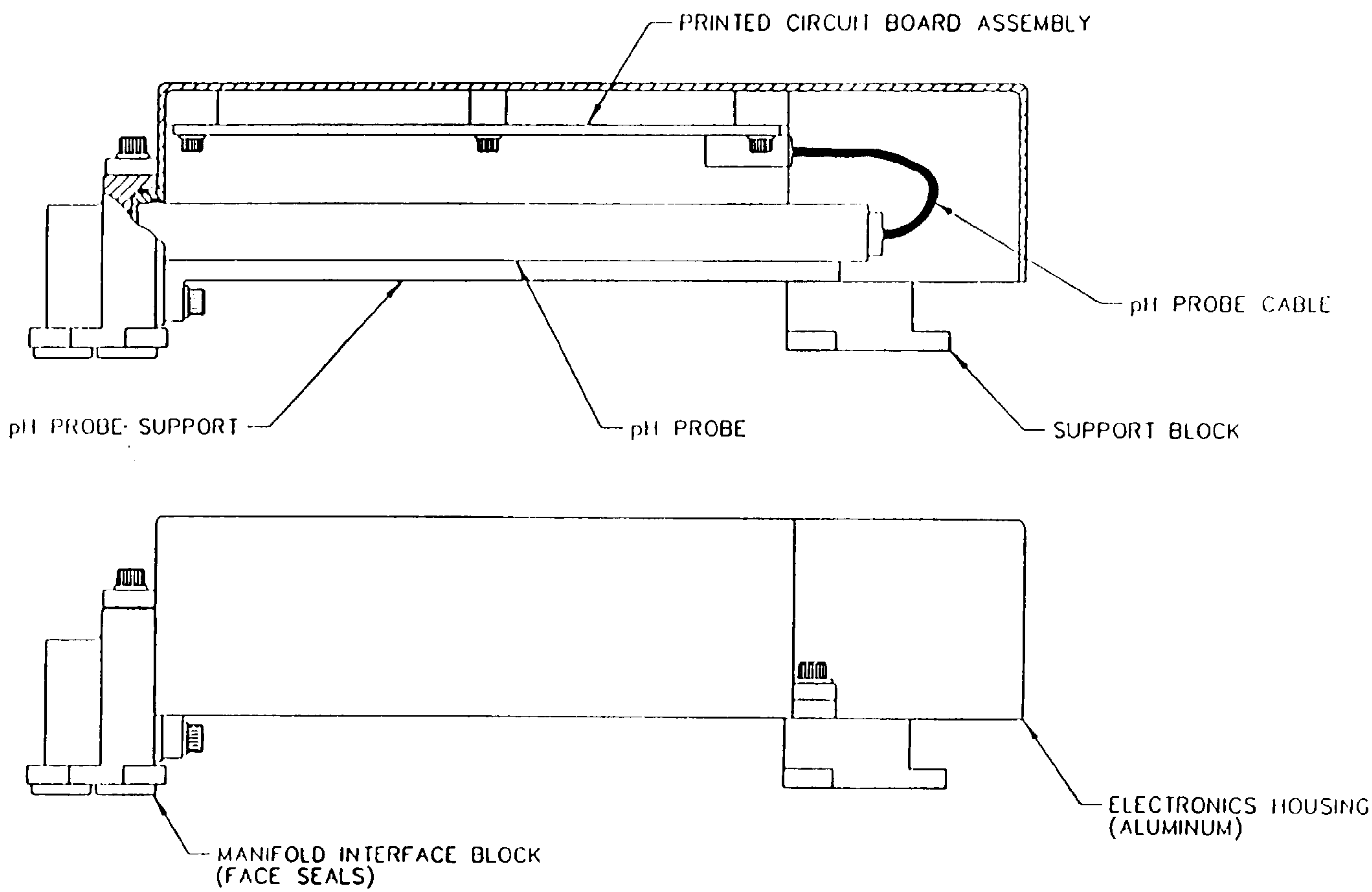
The pH sensor design results in the following derived functional requirements:

- Operating flow rate = 1 - 5 ml/min

BOEING

pH SENSOR

DESIGN



BOEING

SOLID PHASE CALIBRATION STANDARDS

REQUIREMENTS - SOLID PHASE PRECONDITIONER

The Solid Phase Preconditioner (SPP) design results in the following derived nominal operating requirements:

- Flow rate = 1 ml/min
- Conductivity range = 1 - 30 μS/cm
- pH range = 5 - 9 pH units
- TOC range = 50 - 1000 μg/l
- Iodine range = 0.1 - 6.0 mg/l
- Temperature range = 50 - 150 °F
- TIC range = 0 - 5 mg/l

ASTRO BOEING

SOLID PHASE CALIBRATION STANDARDS

REQUIREMENTS - LOW SOLID PHASE CALIBRATION STANDARD

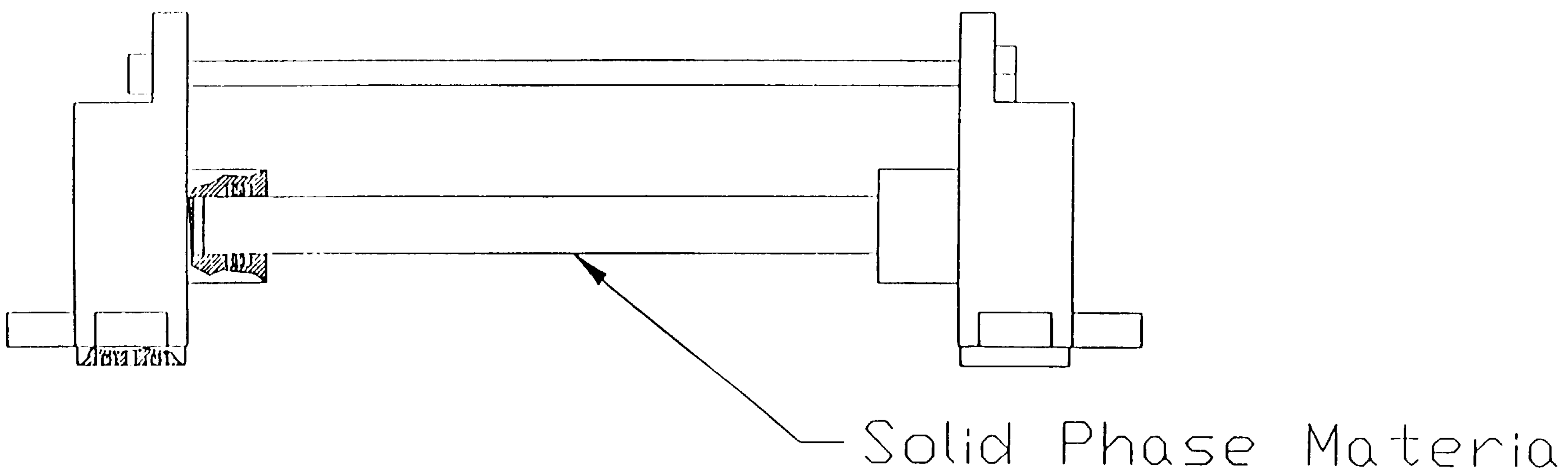
The Low Solid Phase Calibration Standards design results in the following derived functional requirements:

- Preceded by a Solid Phase Preconditioner (SPP)
- Effluent pH range = 3 - 5 pH units
- pH stability over operational life = ± 0.1 pH units
- Operational life span = 300 20 minute cycles

BOEING

SOLID PHASE CALIBRATION STANDARDS

DESIGN



BOEING

TOC MEASURING SYSTEM

REQUIREMENTS

The PCWQM-SEU requires TOC measurement with the following specifications:

- Measuring range = 100-1000 $\mu g/l$
- Sensitivity/tolerance = $\pm$ 50 ppb

BOEING

SOLID PHASE ACIDIFIER

REQUIREMENTS

The solid phase acidifier design results in the following derived functional requirements:

- Effluent < 4.0 pH units
- TOC contribution < 10 μg C/l
- Operational life span = 2880 hours (Equivalent to 211.2 liters throughput)

SOLID PHASE ACIDIFIER

REQUIREMENTS

The solid phase acidifier design results in the following derived nominal operating requirements:

- Flow rate = 1 and 5 ml/min
- Conductivity range = 1 - 120 μS/cm
- pH range = 3 - 10.5 pH units
- TOC range = 50 - 1000 μg/l
- Iodine range = 0.1 - 6.0 mg/l
- Temperature range = 50 - 150 °F
- TIC range = 0 - 5 mg/l

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BOEING

TIC GAS/LIQUID SEPARATOR

REQUIREMENTS

The Total Inorganic Carbon/Gas Liquid Separator (TIC/GLS) design results in the following derived requirements:

- TIC residual $< 30\ \mu g$ C/l at a TIC influent ≤ 5 mg C/l
- TIC operating range = 0 - 5 mg C/l
- Provide oxygenation greater than 20 mg O_2/l at 1 atmosphere
- Influent pH < 4.0 pH units
- Operational flow rate = 1 ml/min
- Operating temperature range = 50 - 150 °F
- Operational performance insensitive to orientation (simulated zero G)
- O_2 influent flow rate = 20-50 sccm

UV REACTOR

REQUIREMENTS

The UV reactor design results in the following derived requirements:

- Oxidation $\geq$ 90 % with TOC sample of urea $\leq$ 1.5 mg C/l
- Operational influent pH < 4.0 pH units
- Operational flow rate = 1 ml/min
- Operating temperature range = 50 - 150 °F

BOEING

UV BALLAST

REQUIREMENTS

- UV REACTOR STEPUP, HIGH VOLTAGE OUTPUT TRANSFORMER
  - Envelope and mechanical interface defined in SK683-20929 of April 9, 1993
  - Two primary coils rated for 100 volts max.
  - Two secondary coils rated for 4000 volts max (40:1 turns ratio each)
  - Encapsulated; Electrical terminals are MIL-T-55155/15C
  - Qualified to MIL-STD-981 Class S consistent with MIL-STD-975J

* Specifications are to change per October 27, 1993 UV Ballast PDR Telecon

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BOEING

CARBON DIOXIDE DETECTOR

REQUIREMENTS

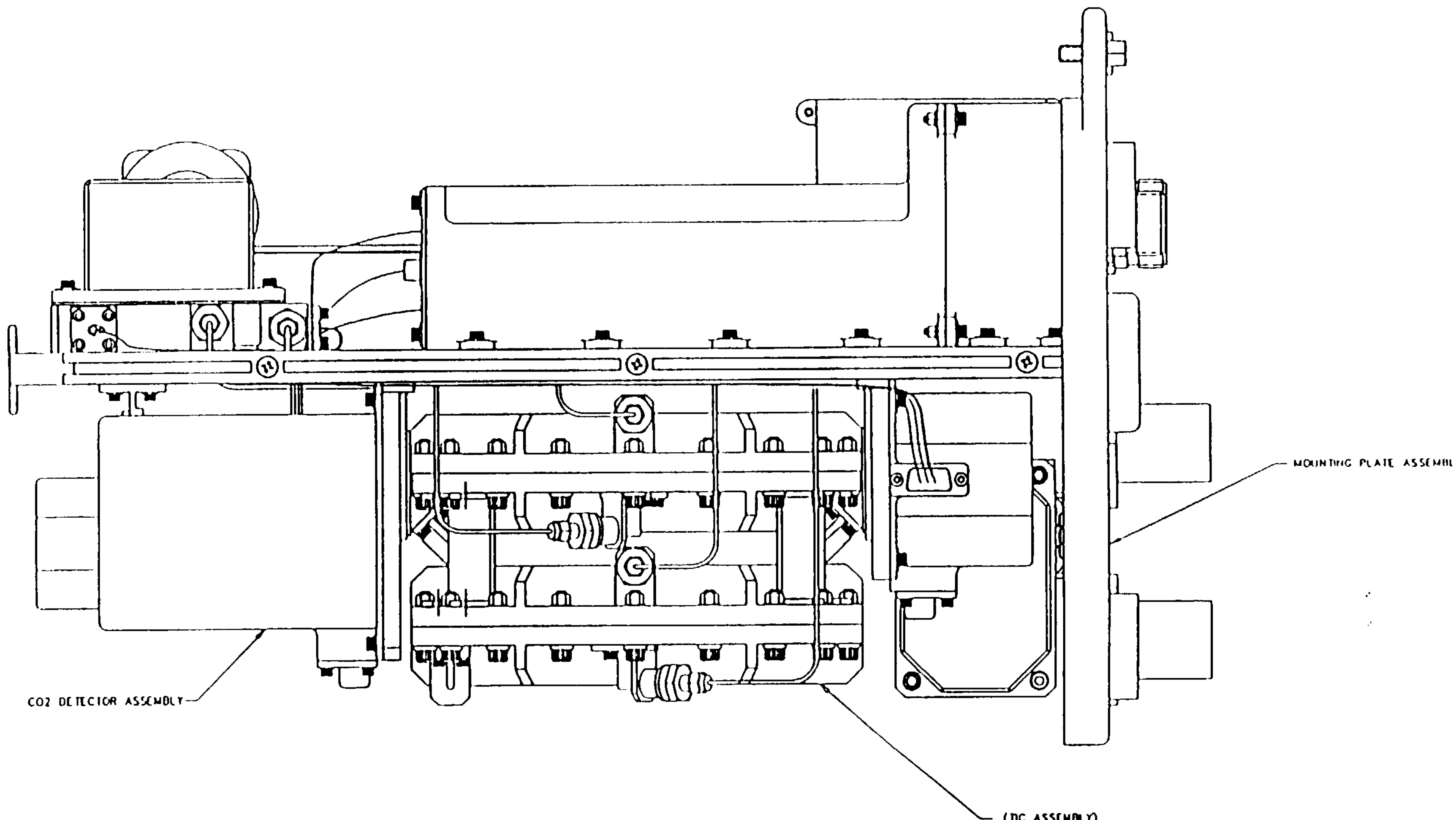
The CO_2 detector design results in the following derived operating requirements:

- Temperature range = 50-104 °F
- Flow rate = 1 ml/min ± 0.01 ml/min
- Inlet sample pH ≤ 4
- Inlet TIC residual ≤ 30 μg C/l
- 90% of sample TOC in the form of CO_2 (minimum)
- CO_2 detector cell surface ≥ 1 °C above inlet temperature of sample
- O_2 flow rate = 0-275 sccm

BOEING

COMPONENT LEVEL DESIGN

SYSTEM OVERVIEW



LEFT SIDE VIEW

BOEING

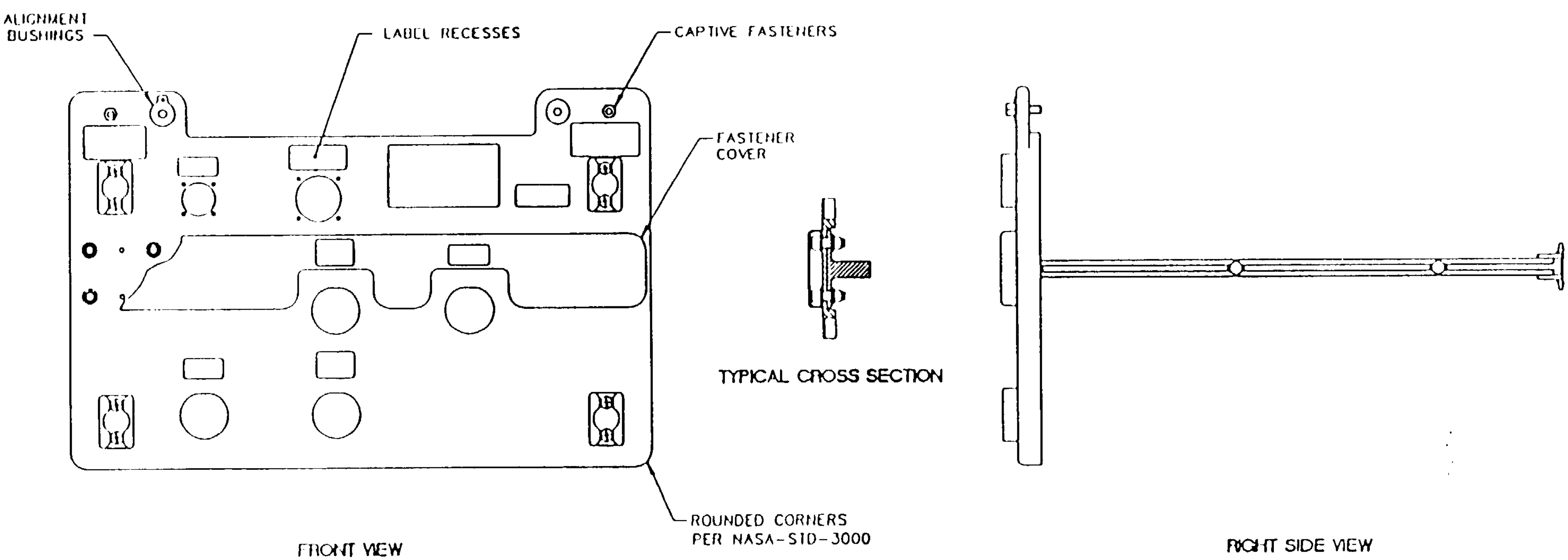
MOUNTING PLATE ASSEMBLY

REQUIREMENTS

- Change in front panel attachment points from center plane to top of front panel from ICD resulted in redesign. Requires more rigid (heavier) front panel due to cantilevered mounting of front panel.
- Front panel shall meet human factors of NASA-STD-3000 for rounded corners, connector spacing, attachment points
- Mounting plate assembly shall be self aligning, require no complex actions, unable to be installed in the wrong orientation
- Support PCWQM-SEU component assemblies during launch vibration, acceleration, and crew induced loads
- 1-g installation/removal force shall be less than 35 lbs
- Provide conduction path for heat rejection from components to integral heat exchanger
- Fasteners removable on orbit must be captive

MOUNTING PLATE ASSEMBLY

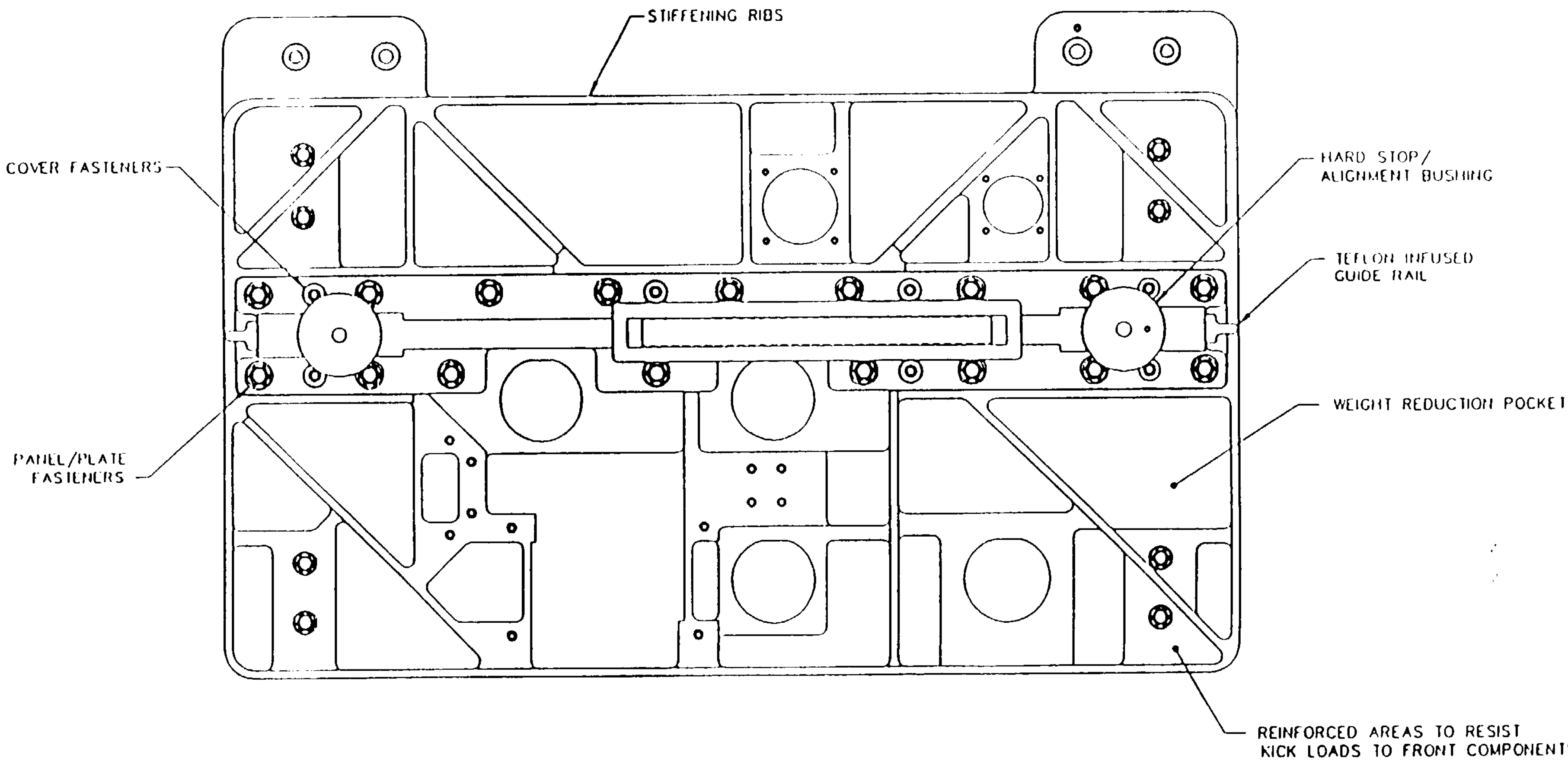
DESIGN



BOEING

MOUNTING PLATE ASSEMBLY

DESIGN



REAR VIEW

BOEING

MOTOR/PUMP AND CONTROLLER

REQUIREMENTS

The motor/pump design results in the following derived requirements:

- Flow rate = 1 and 5 ml/min
- Pressure rise = 10 -25 psig
- Flow stability = ± 0.01 ml/min @ 1 ml/min
- Flow stability = ± 0.25 ml/min @ 5 ml/min

SAMPLE MANIFOLDS

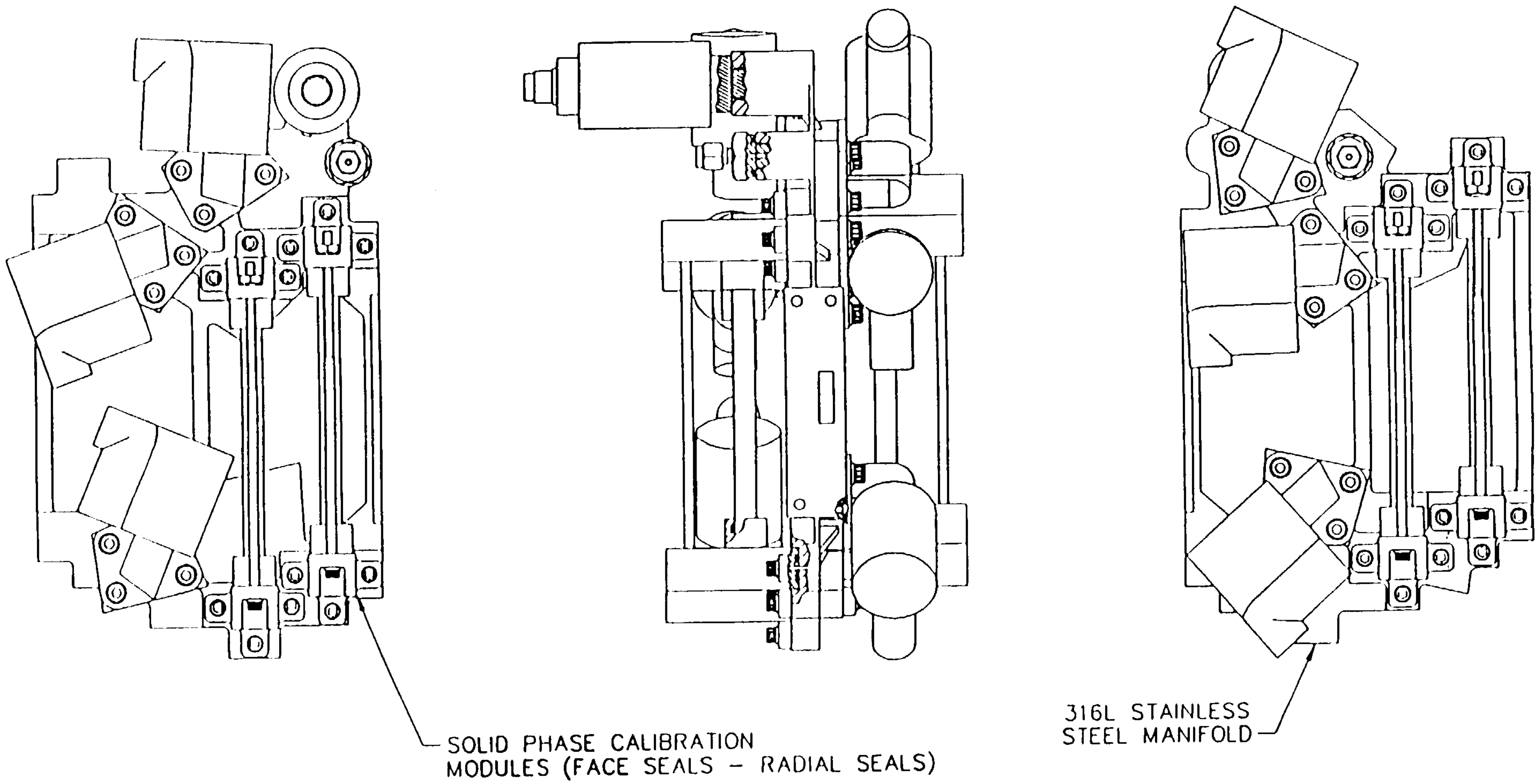
REQUIREMENTS

- Minimize the requirement for tubing runs by grouping components onto manifolds
- Reduce the risk of leakage by mounting interconnected components on opposite sides of the manifold and by using drilled holes
- Reduce sensitivity to variation on multi-port components by using static face seals against the manifold
- Minimize manifold size and weight
- Locate heat generating components as close as possible to the avionics air heat sink
- Profile manifolds where required to maintain clearance to other subassemblies

BOEING

SAMPLE MANIFOLD

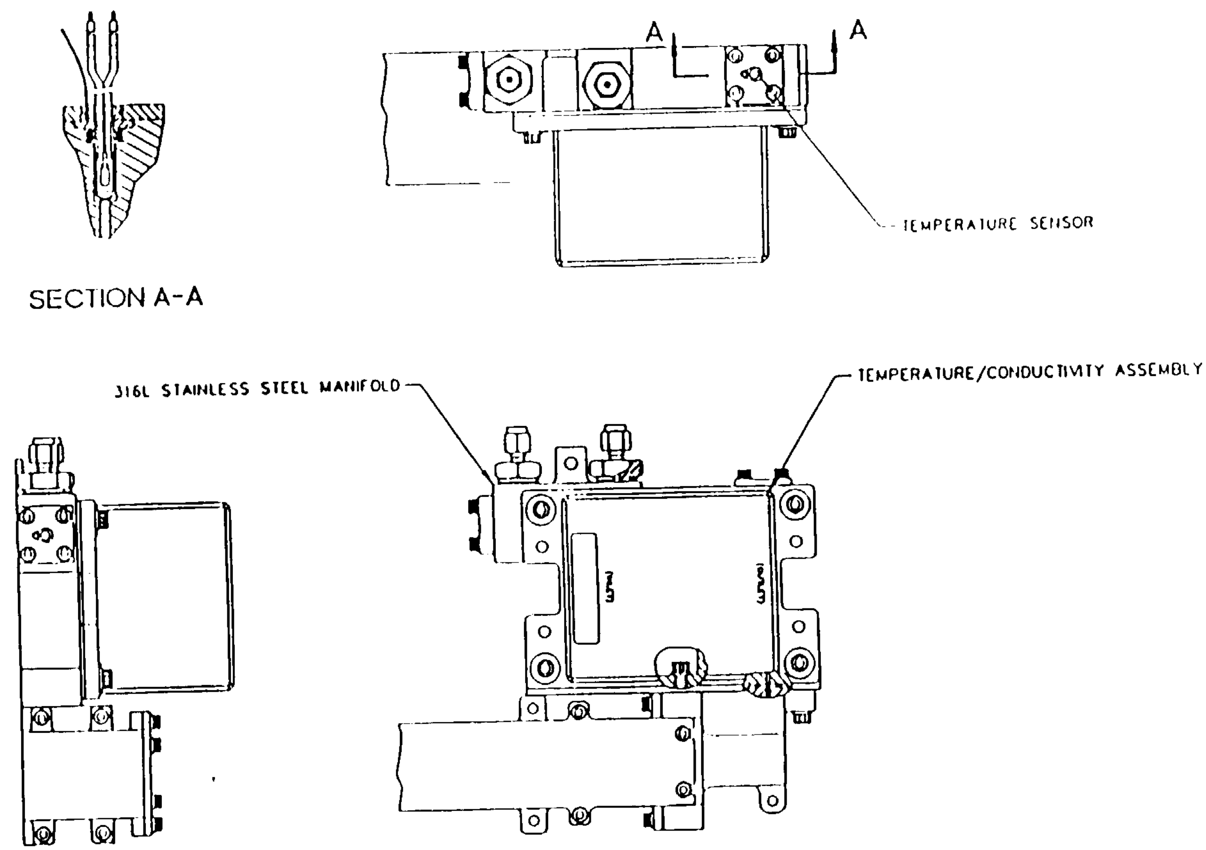
DESIGN - SAMPLE MANIFOLD 1



BOEING

SAMPLE MANIFOLD

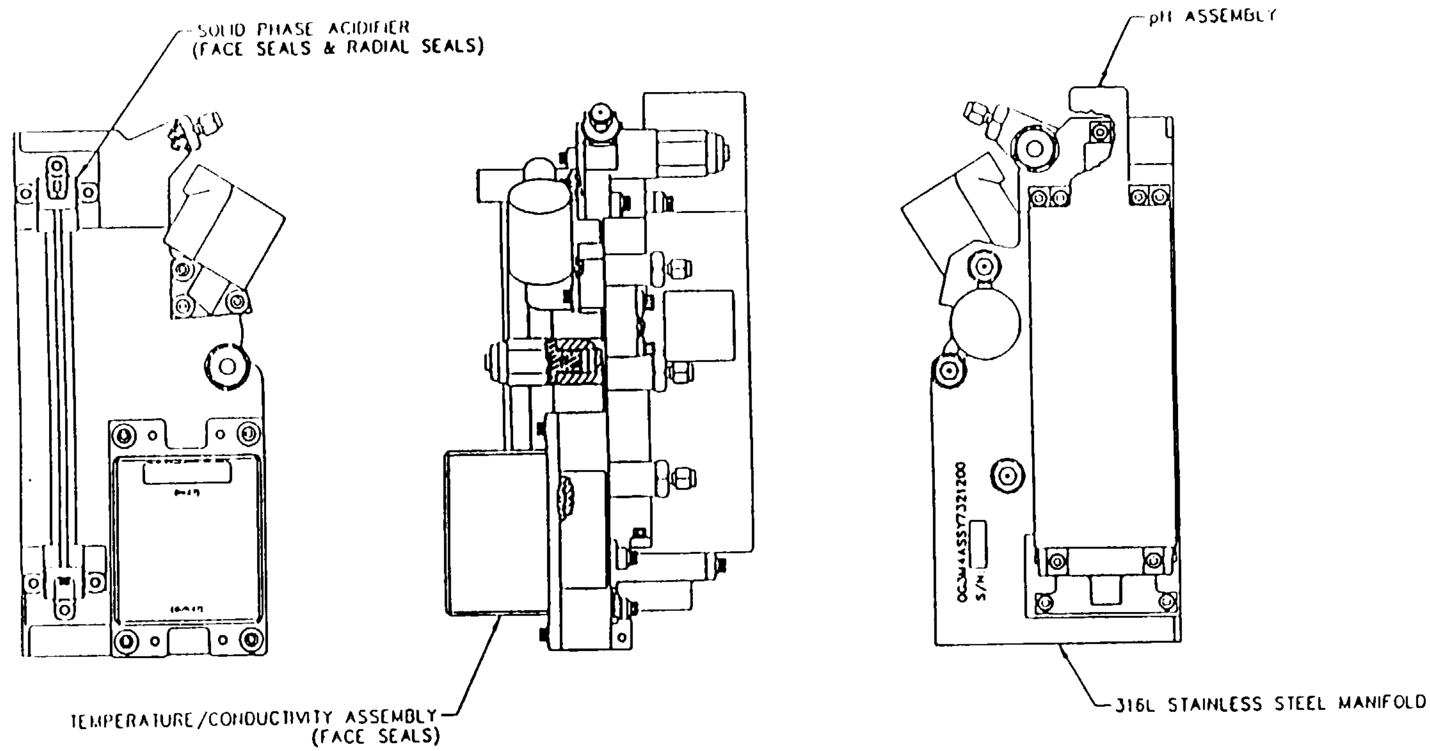
DESIGN - SAMPLE MANIFOLD 2



BOEING

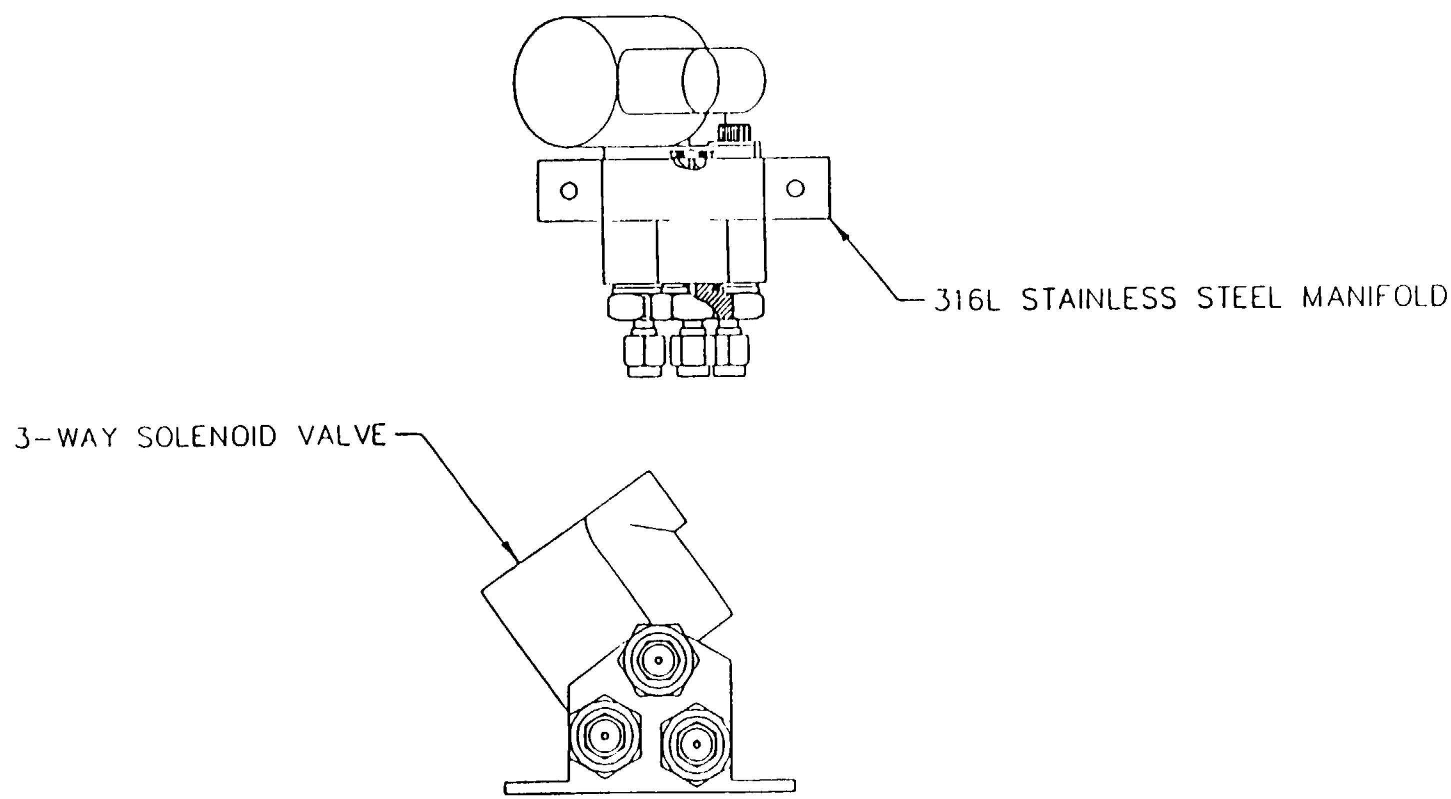
SAMPLE MANIFOLD

DESIGN - SAMPLE MANIFOLD 3



SAMPLE MANIFOLD

DESIGN - SAMPLE MANIFOLD 4



ASTRO

BOEING

SENSOR/EFFECTOR ADDRESS DECODER

REQUIREMENTS

SEAD ANALOG SIGNAL FUNCTIONAL REQUIREMENTS:

- 32 channels of single ended analog inputs with range of -10 to +10 volts dc
- Static input voltage accuracy of ± 0.003% of Full Scale Range (FSR) at a 1 kHz sampling rate
- Static input voltage resolutionaccuracy of at least 610 μV/Least Significant Bit (LSB)
- Dynamic error < ± 0.0224% FSR at a signal slew rate of 0.5 volts per second at a 10 kHz sampling rate
- Provide interface to firmware controller via 2 wire/line RS-422 balanced receivers/drivers
- Cabable of receiving or transmitting 16 bit wide data bus signals
- Cabable of storing, semipermanently, minimum 2K x 8 bit sensor calibration coefficients

BOEING

SENSOR/EFFECTOR ADDRESS DECODER

REQUIREMENTS

SEAD DIGITAL SIGNAL FUNCTIONAL REQUIREMENTS:

- 16 Transistor-Transistor Logic (TTL) channels of digital input with the following characteristics:
  - Minimum high level input voltage is $V_{IH} = 2.0$ volts
  - Maximum low level input voltage is $V_{IL} = 0.8$ volts
- 32 channels of digital output with the following characteristics:
  - Minimum high level voltage $V_{OH} = 2.4$ (Min) with an output current of $I_{OH} = -4.0$ mA
  - Maximum low level voltage $V_{OL} = 0.45$ (Max) with an output current of $I_{OL} = 8.0$ mA

BOEING

SENSOR/EFFECTOR ADDRESS DECODER

REQUIREMENTS

SEAD SAMPLE RATE FUNCTIONAL REQUIREMENTS

- Maximum sample rate frequency of 10 kHz
- Sample rate accuracy of ± 50 Hz
- Sample rate stability of ± 1% of the setting

SEAD BIDIRECTIONAL DATA BUS COMMUNICATION FUNCTIONAL REQUIREMENTS

- The input command yields the appropriate output effector command 100% of the time

BOEING

SENSOR/EFFECTOR ADDRESS DECODER

REQUIREMENTS

SEAD VALVE DRIVER CIRCUIT FUNCTIONAL REQUIREMENTS

- Provide PWM drive to valve with 0.14% duty cycle after initial drive of +28 volts fopr 50 ms.

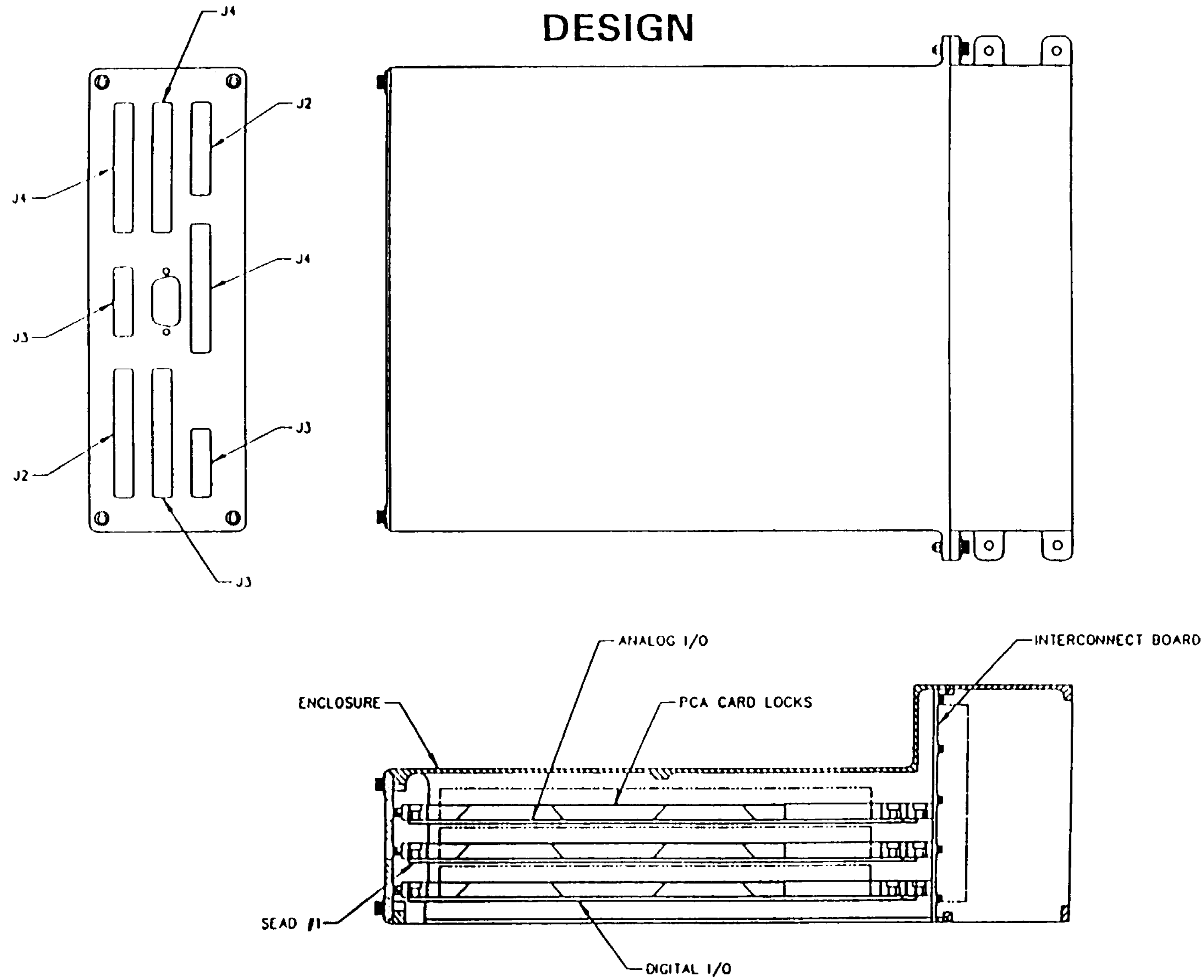
SEAD CONDENSATE DETECTOR CIRCUIT FUNCTIONAL REQUIREMENTS

- Convert the condensate detector's analog signal to a 1 bit digital signal

BOEING

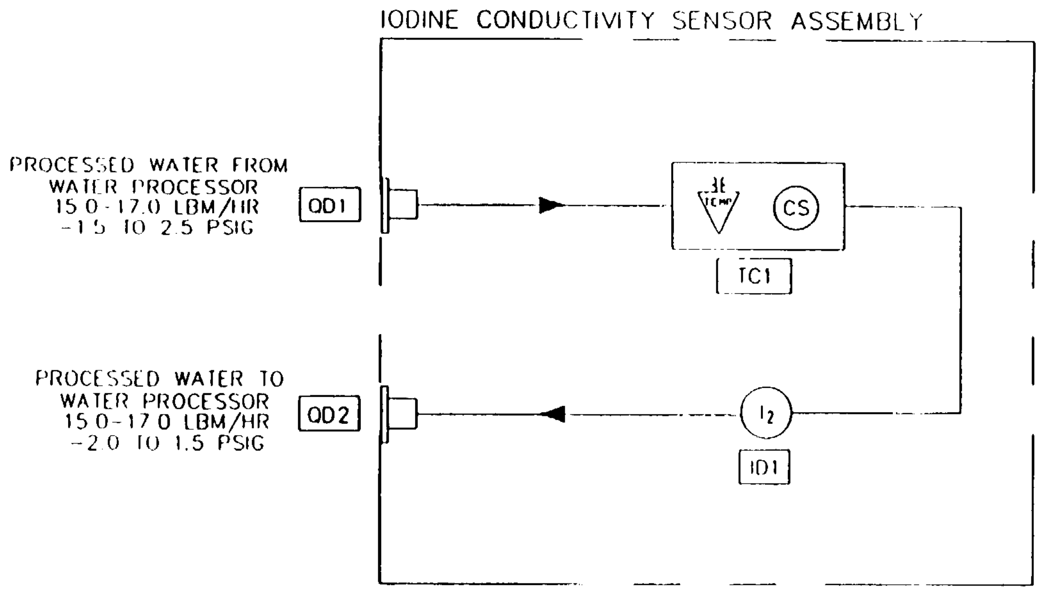
SENSOR EFFECTOR ADDRESS DECODER

DESIGN

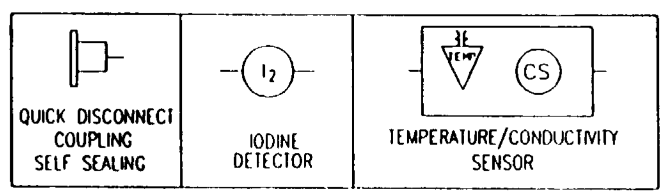


ICSA Program Design Status

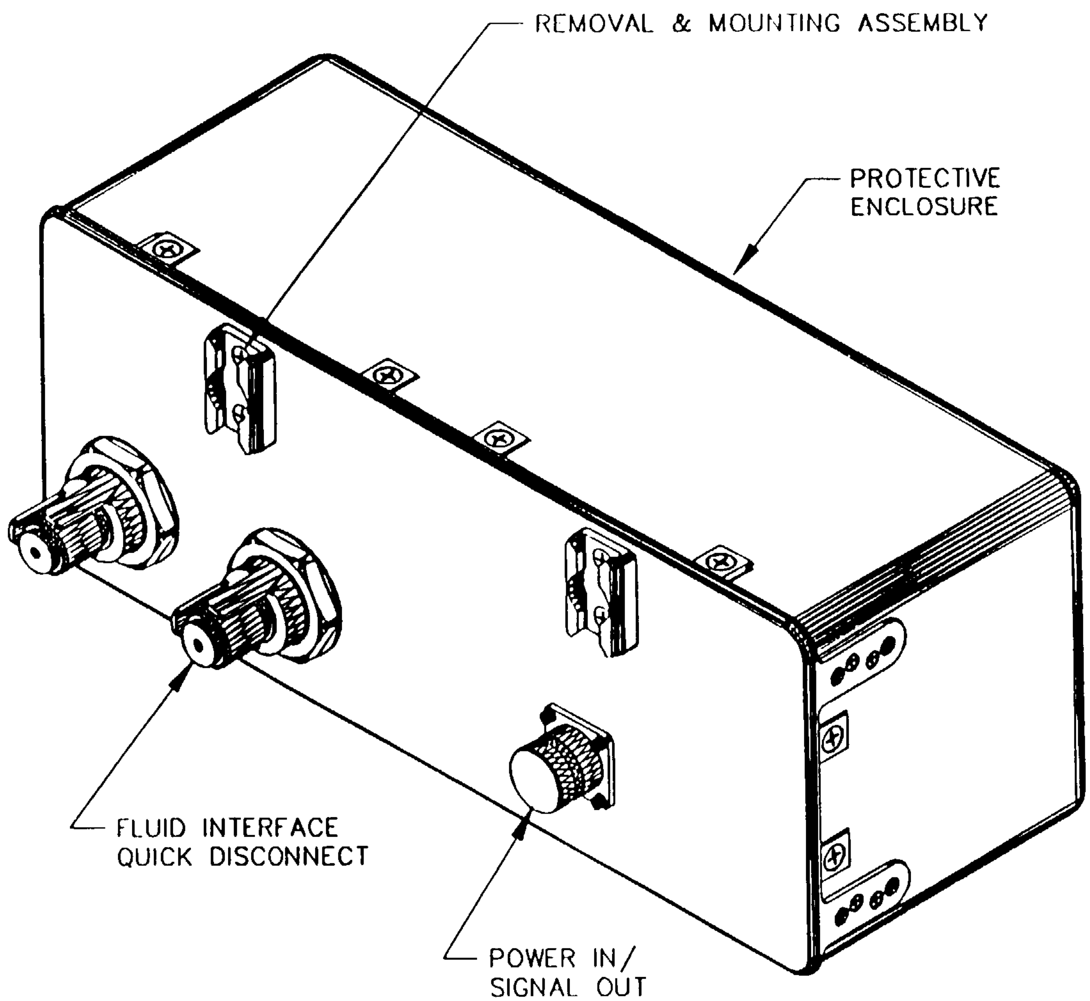
- Boeing directed change from PCWQM-SEU to ICSA configuration effective March 31, 1995
- Deliverables:
  - 1 Pre-Production prototype Unit [PPU]: A) work out any layout bugs; B) built w/Class B EEE parts or parts from Class S lot being tested; C) verify calibration and test procedures; D) Boeing planned to ultimately deliver to Hamilton Standard to assist in WP integration.
  - 1 Protoflight Unit [PFU]: A) supposed to be 100% Class S EEE parts; B) reduced Qual Test levels; C) intended to be used for Flight.
  - STE: Automated test system designed for calibrating and performing ATP for PCWQM and ICSA.



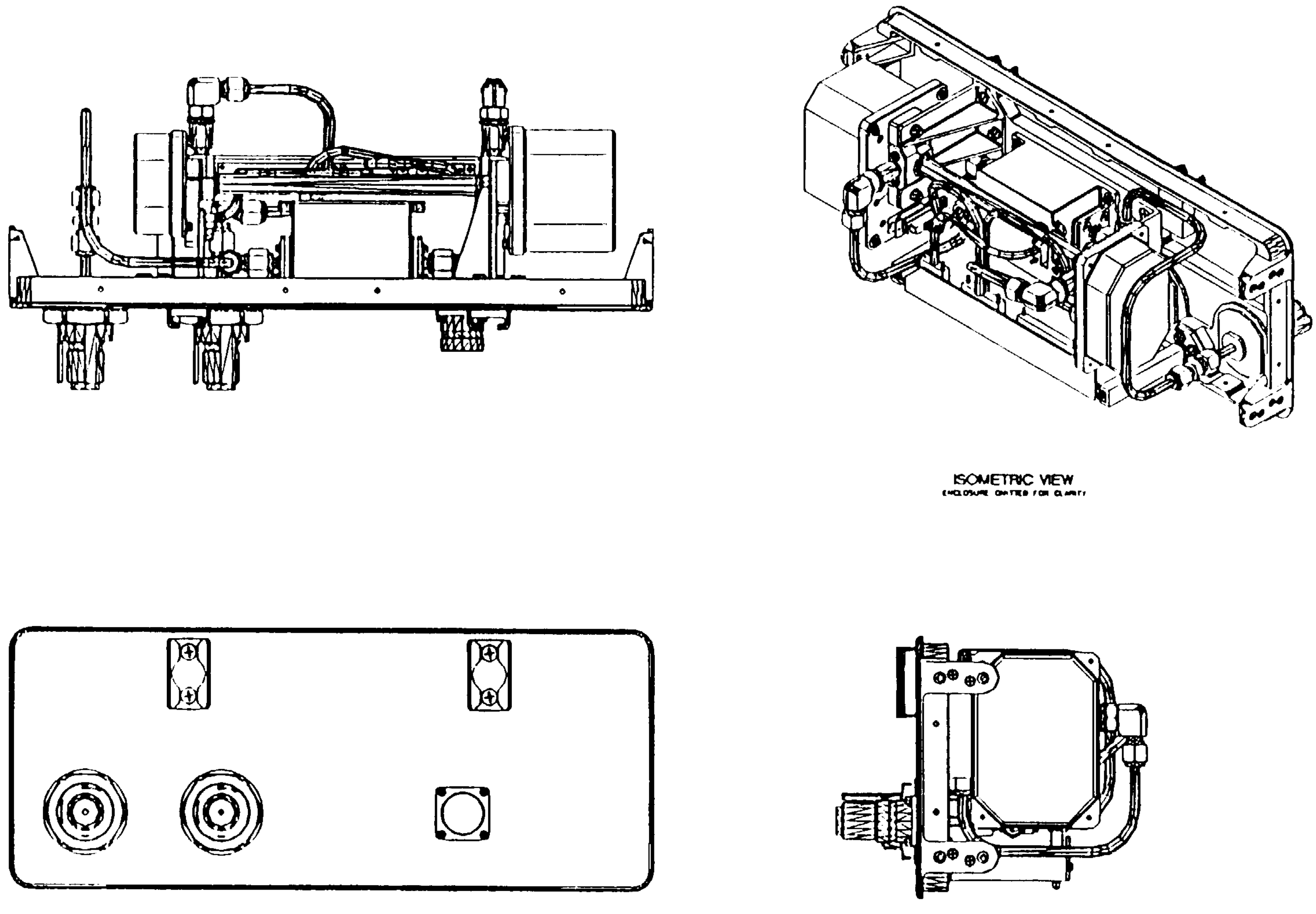
LEGEND:



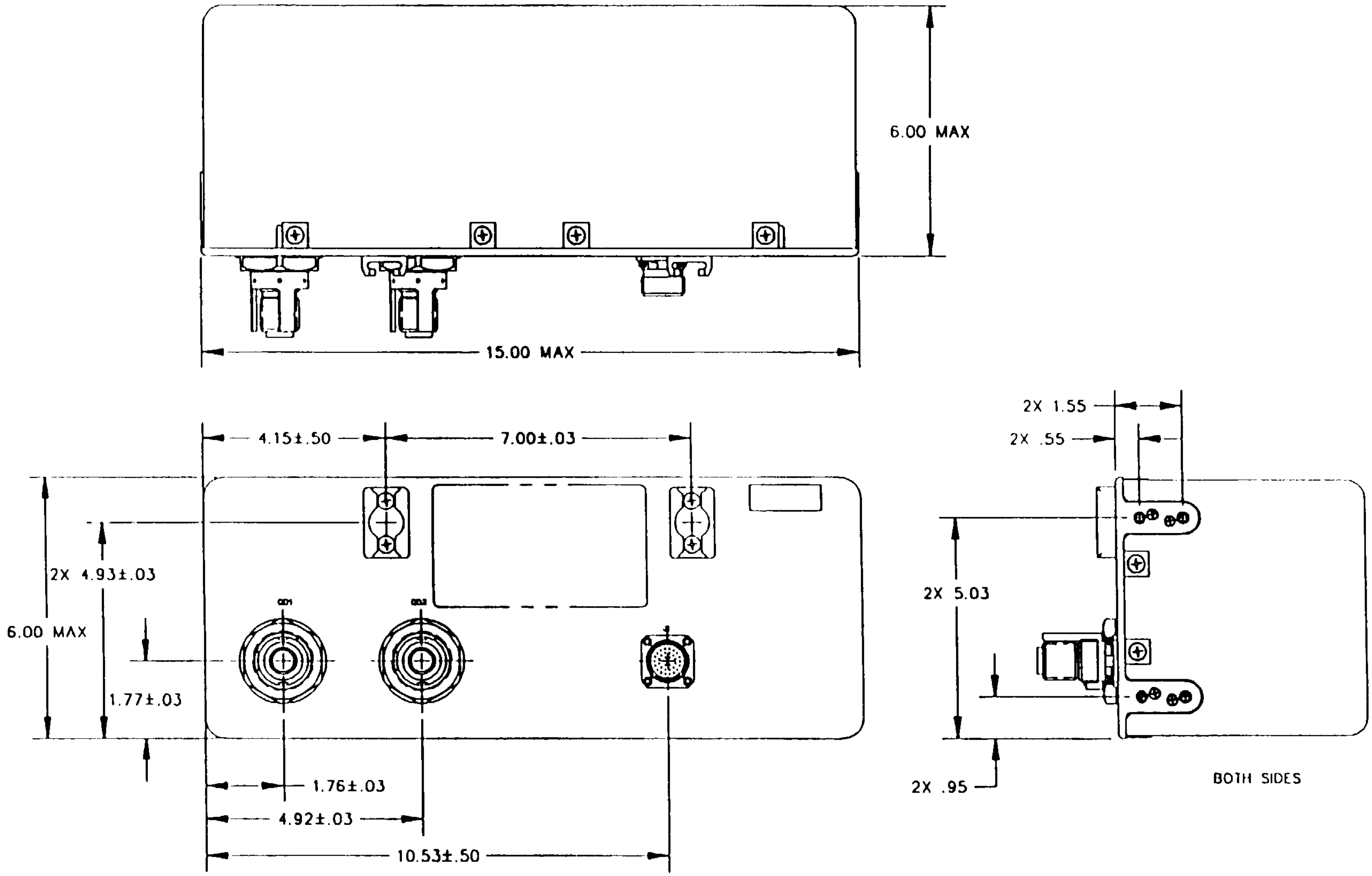
ICSA Flow Diagram



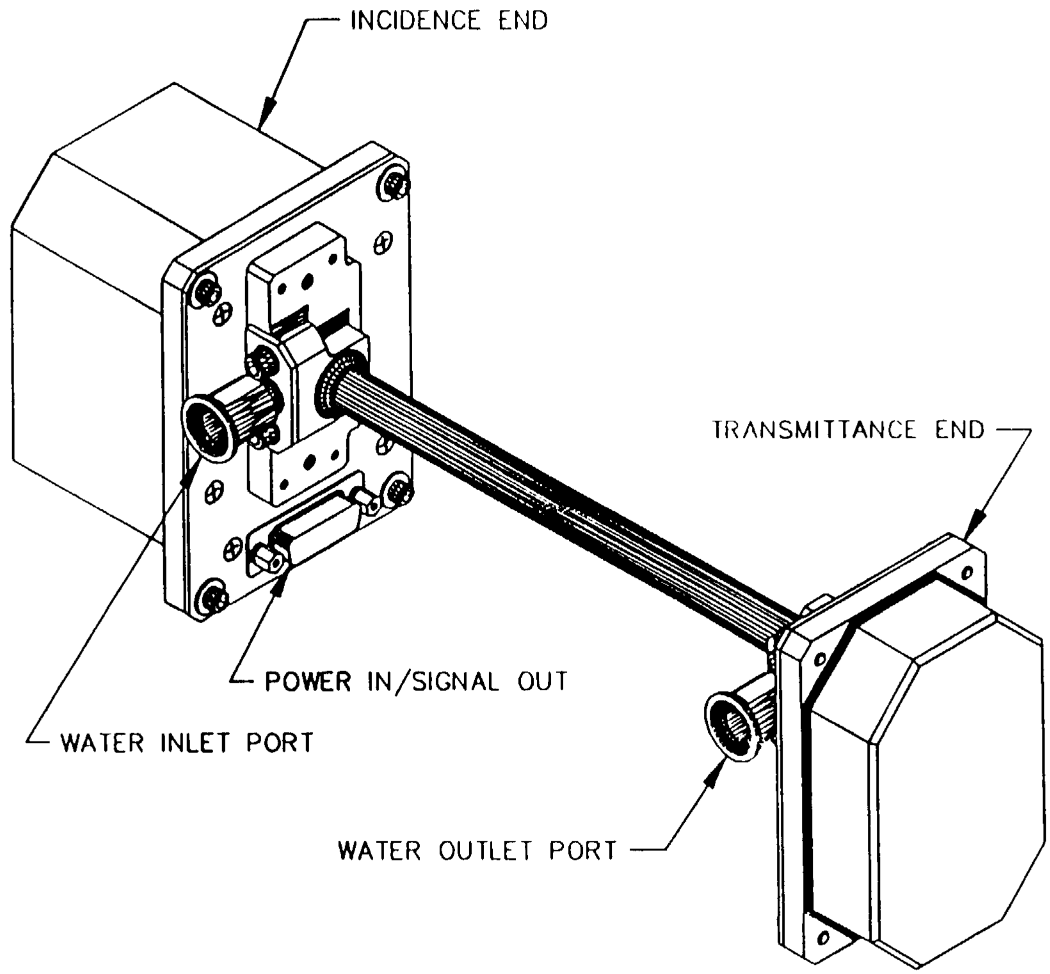
ICSA Mechaincal Interface Components



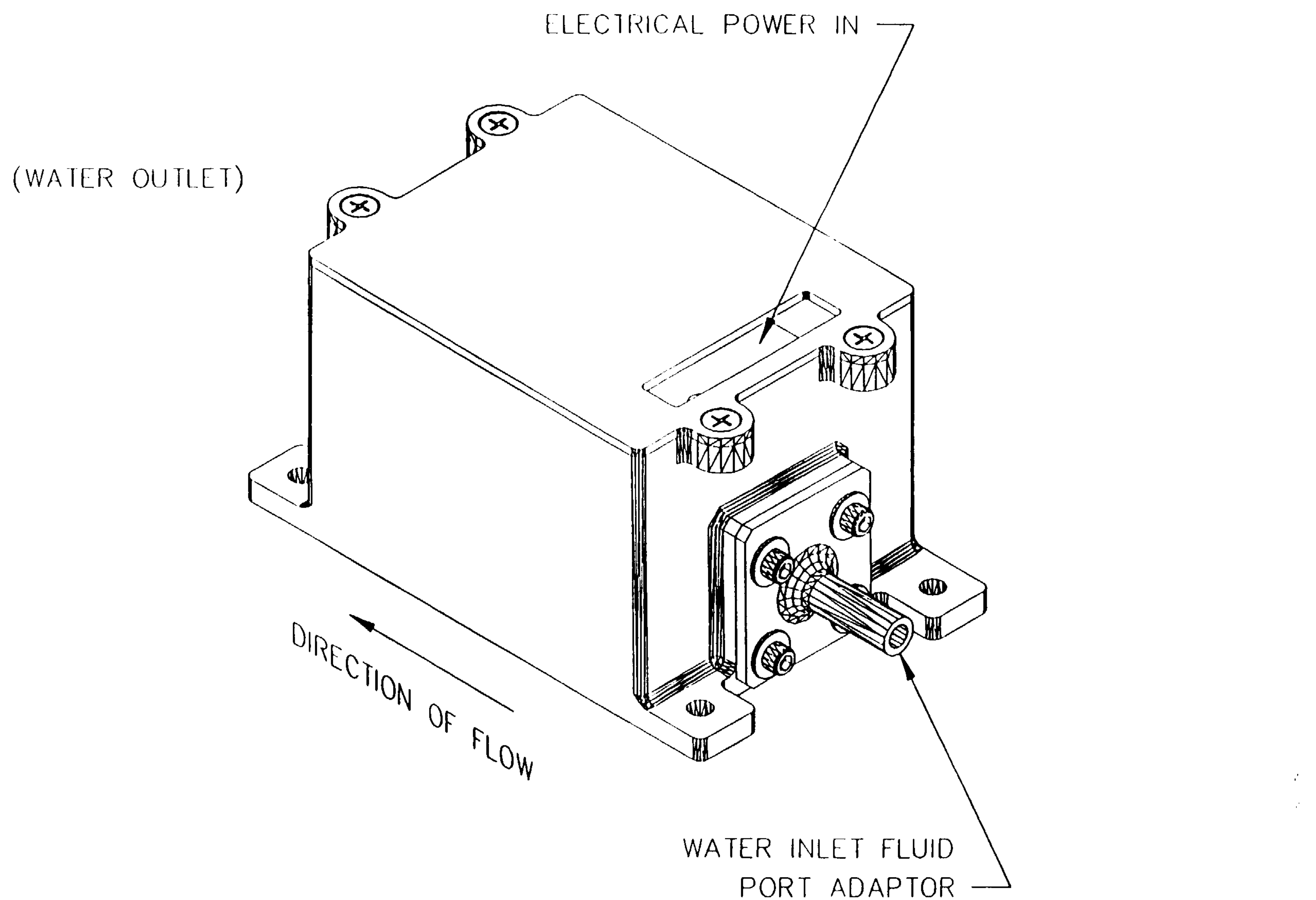
Iodine-Conductivity Sensor Assembly



ICSA Mechanical Interface Dimensions



Iodine Detector



Temperature/Conductivity Sensor - Process Loop

ICSA Program Design Status

- Open Issues/Status:
  - PPU meet objectives stated above. ∴ no issues (Not for Flight!)
  - Boeing directed ZALC to complete build of PFU with some non-Class S EEE parts (upscreened DESC parts; red LED; AD590 temp sensor)
  - Calibration was performed as required
  - ATPs were modified to reduce Schedule: no thermal cycling; limited full range temperature sensor performance verifications; no Vibe; no EMI; no pressure or vacuum.
  - Boeing's plan was to take PFU apart, install correct Class S parts, re-calibrate, execute PFU Qual ATP using STE

ICSA Program Design Status

ICSA Design considered a success that exceeded performance requirements (60 hour ATP):

- "Temperature sensitivity/tolerance of ±1.0°F over range of 50 to 150°F"

  ATP data: ±0.12°F {±0.61°F (3 σ)}

- "Conductivity sensitivity/tolerance of ±1.0 μS/cm over range of 1 to 30 μS/cm compensated to 25°C using SRM 3190 as reference standard"

  ATP data: ±0.12 μS/cm {±0.88 (2 σ)}

ICSA Program Design Status

- "Iodine Sensor sensitivity/tolerance of ±0.2 ppm over range of 0.1 to 6.0 mg I_2/L at iodine-iodide equilibrium in WP H_2O and constant pH"

  ATP data: ±0.11 mg I_2/L over range (1 σ)
- All ICSA hardware & documentation and PCWQM-SEU documentation shipped to Boeing April 25, 1997

- ZALC assumes current plan is to recover PPU & PFU ICSAs for use within PCWQM where appropriate
- ZALC also assumes STE will be recovered for use by PCWQM Program

1997 PCWQM Program Development

- ION Associates funded further development work towards PCWQM under "lessons learned" from Stage 10.
- Conclusions of Studies done for ION:
  - ZALC-SS-1601: GLS membrane material ***is*** available from alternative vendors
  - ZALC-SS-1600: "membrane failures" were not failures of membrane material: 2 caused by spacing shims (subsequent design has eliminated them); 1 caused by defective o-ring (subsequent assembly procedures call for microscopic inspection prior to incorporation into unit)

1997 PCWQM Program Development

- Conclusions of Studies done for ION (continued):
  - ZALC-SS-1602: Recommend further life testing to justify >1 yr life for ISFET probe (ORU3); or could replenish electrode gel on-orbit
  - ZALC-SS-1603: baslined Honeywell (nee Leeds & Northup) pH probe still available and no problems in future procurement expected; alternative vendors available, but design impacted.
  - ZALC-SS-1606: UV Ballast power supply subcontractors do exist and could cost effectively design/manufacture to Class B type requirements.

1997 PCWQM Program Development

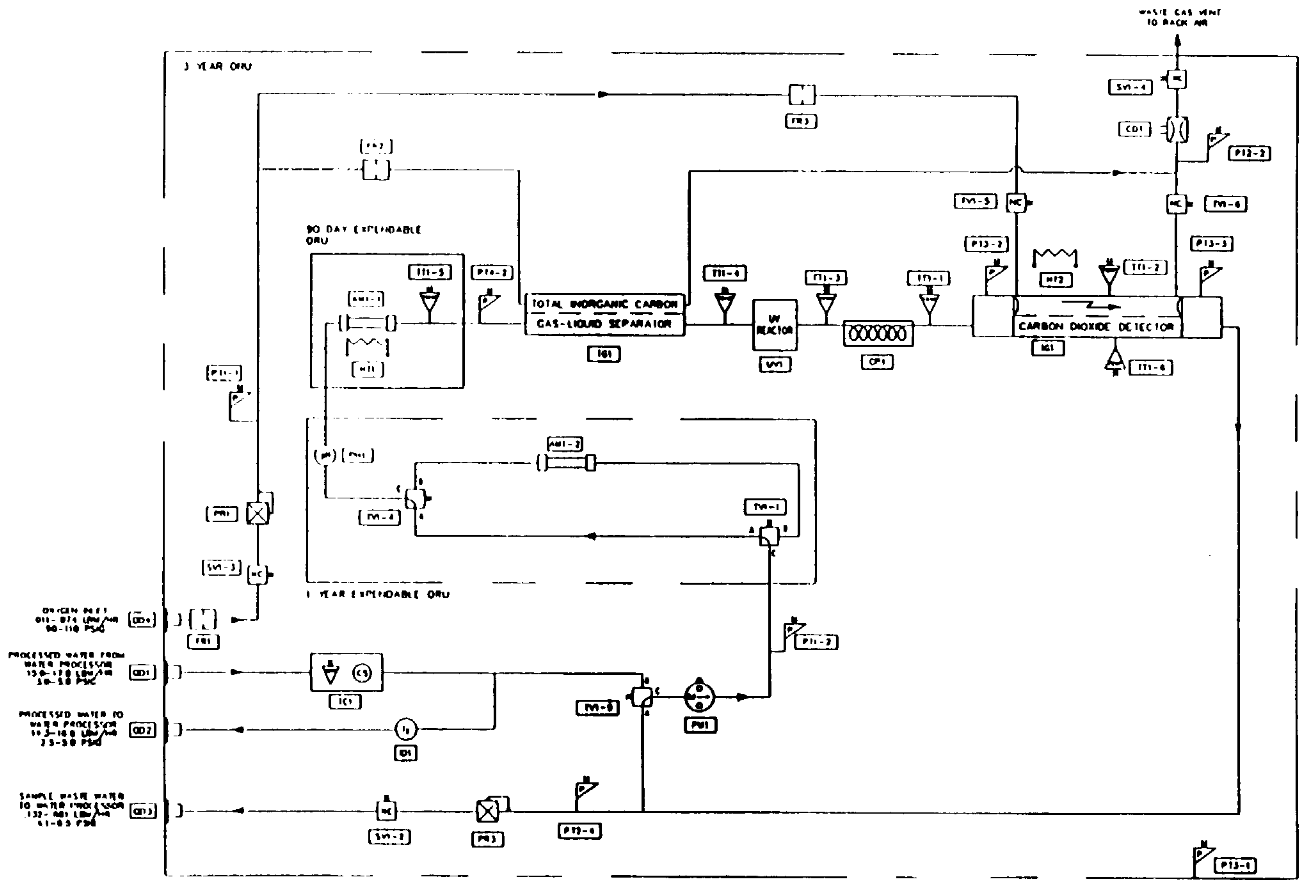
- Conclusions of Studies done for ION (continued):
  - ZALC-SS-1607: Suggest incorporation of 254 nm solid state detector into UV Lamp Assembly to monitor intensity.
  - ZALC-SS-1608: TOC measurement range extension to 5000 ppb TOC can happen with virtually no impact if accuracy requirement set to ±5% of reading over 1 to 5 ppm range.
  - ZALC-SS-1605: Modeling and packaging study drawings follow, with recommendation that PCWQM incorporate power supplies and firmware controller for a true "turn key" instrument eliminating complex integration.

PCWQM Program Technical History

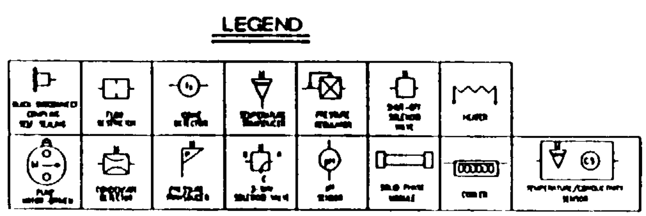
- PCWQM-SEU is a “dumb” assembly relying on external command and control of effectors and sensors.
- Baseline design results in two (2) large connectors:
  J1 = Power: +5, +28, ±15 and associated returns
  J2 = Signal: 32 twisted, shielded pairs
- Boeing to provide cabling up to PCWQM-SEU front panel. . . significant weight
- PCWQM Integration Nightmare:
  - PCWQM-SEU to External DC Power supplies
  - PCWQM-SEU to third party External FWC
  - PCWQM-SEU to third party software

1997 PCWQM Program Development

- Advantages of "self contained" PCWQM:
  - Improves significantly likelihood of successful higher level integration
  - Significantly reduces testing problems
  - Instrument provides a serial data stream (re: Stage 9 and Stage 10 PCWQM) with data already converted to scientific values (calculations already performed, PCWQM state and FDI status provided, overrides available, etc.)
  - Weight delta negligible: compare FWC weight -vs- 32 twisted pairs w/shields, connectors, multiple power lines, etc.



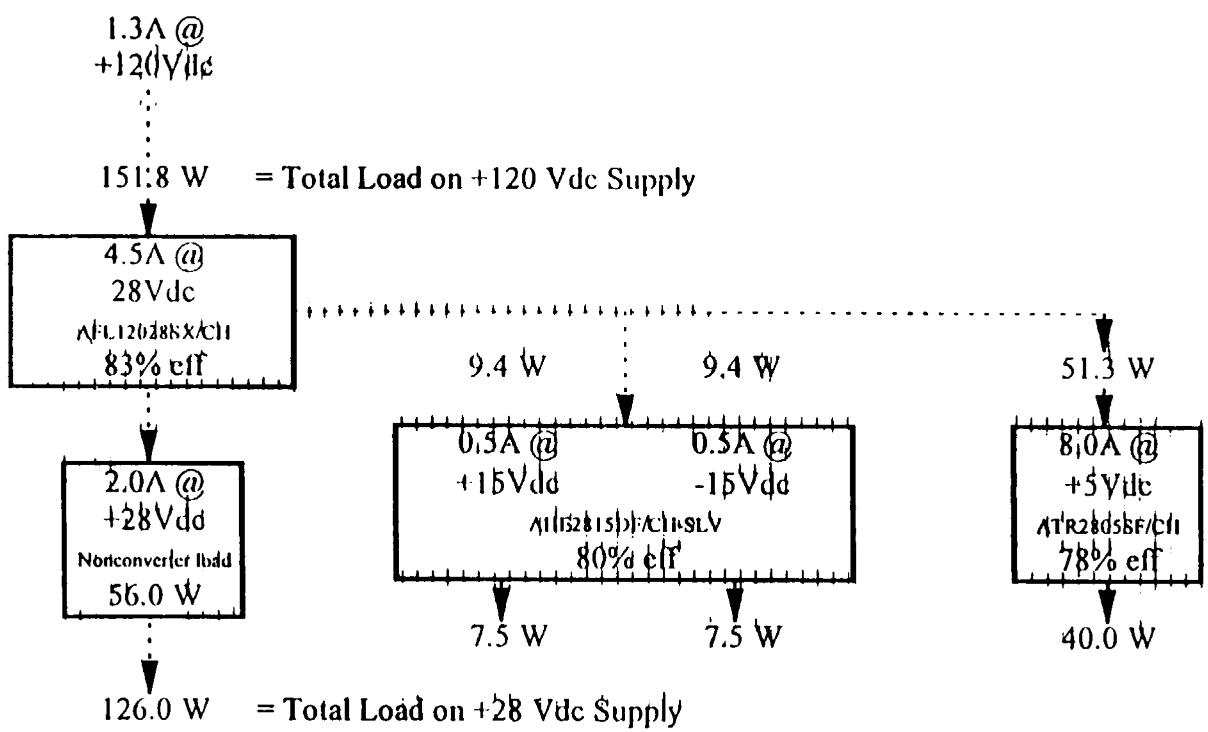
LEGEND



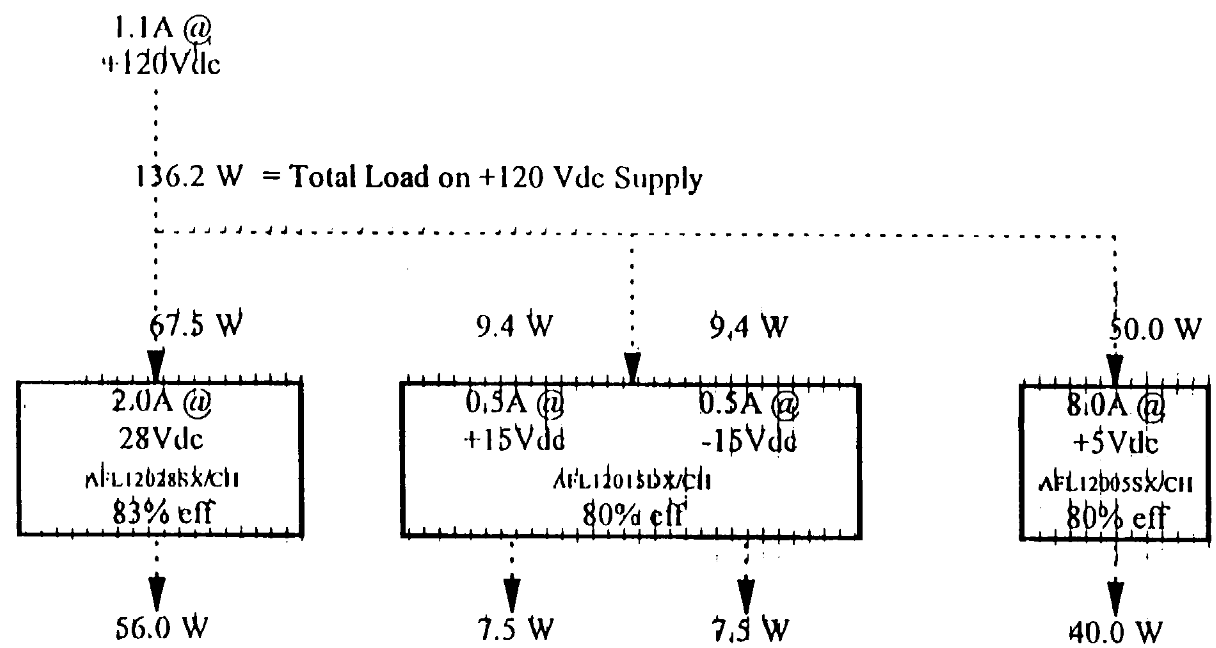
A = COIL A ENERGIZED
B = COIL B ENERGIZED
C = COMMON FLUID PORT
NC = NORMALLY CLOSED WHEN UNENERGIZED
SCCM = STANDARD CUBIC CENTIMETERS PER MINUTE

REFERENCE DESIGNATOR	FUNCTIONAL DESCRIPTION
FR1	FLOW RESTRICTOR (315 SCCM NOMINAL)
FR2	FLOW RESTRICTOR (40 SCCM NOMINAL)
FR3	FLOW RESTRICTOR (275 SCCM NOMINAL)
PR1	PRESSURE REGULATOR (9 PSIG NOMINAL)
PR3	BACK PRESSURE REGULATOR (7.5 PSIG NOMINAL)
PT1	PRESSURE TRANSDUCER (0 - 200 PSIG)
PT2	PRESSURE TRANSDUCER (0 - 10 PSIG)
PT3	PRESSURE TRANSDUCER (0 - 30 PSIA)
PT4	PRESSURE TRANSDUCER (0 - 30 PSIG)
TC1	TEMPERATURE/CONDUCTIVITY SENSOR - PROCESS LOOP -

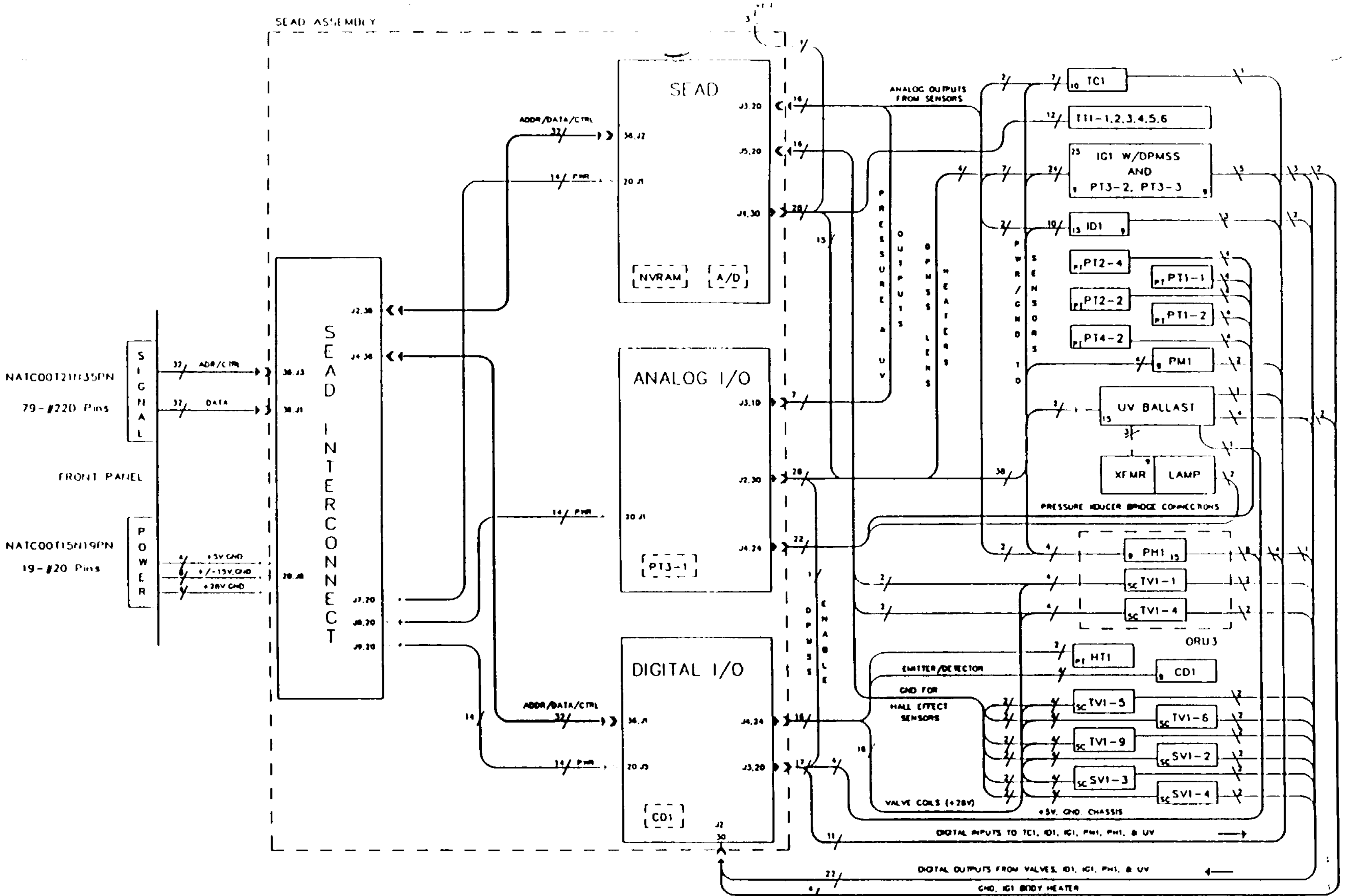
PCWQM Flow Diagram (7330168-00 Rev G)



Two Step Down Power Distribution Approach
POWERLIST.XLS, Scenario #1



Single Step Down Power Distribution Approach
POWEREST.XLS, Scenario #2



LEGEND

A = # OF WIRES
B = CONNECTOR SIZE
C = SENSOR IDENTIFICATION
PT = PIG-TAIL CONNECTION
SC = SOLDERCUP CONNECTION

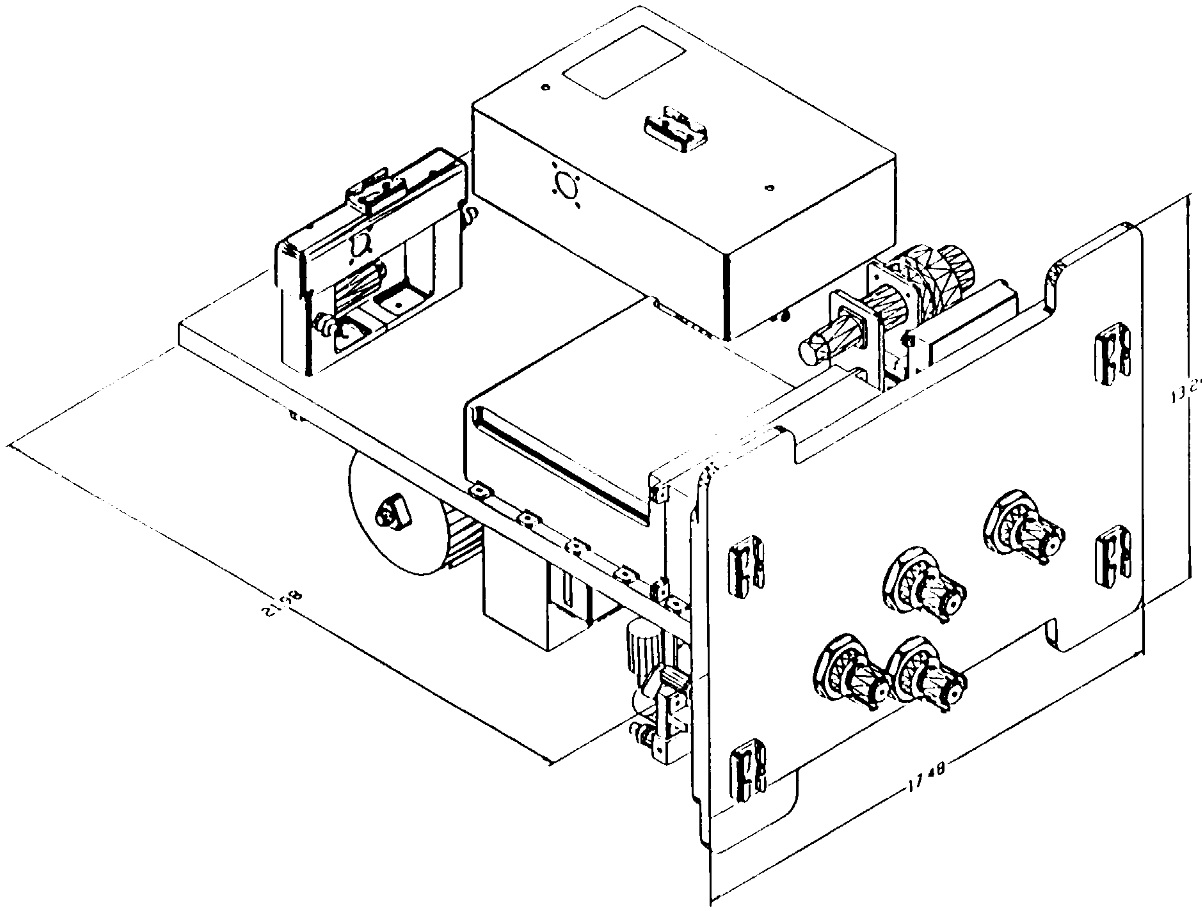
Electrical Interconnect Diagram (7330074-00 Rev D)

Description:	Ref. Des.	Locale	Channel Count (wrt SEAD) Digital Out	Digital In	Analog In
Conductivity	TC1, C	B7	0.5		1
Iodine	ID1	B7	1	2	2
Motor, Metering	PM1	B5	2		
Motor, TOC Stepper	IG1, M	C4	1	1	
pH sensor	PH1	C7	1		1
Pressure Xdcr	PT1-1	C7			1
Pressure Xdcr	PT1-2	B5			1
Pressure Xdcr	PT2-2	D3			1
Pressure Xdcr	PT2-4	B6			1
Pressure Xdcr	PT3-1	B4			1
Pressure Xdcr	PT3-2	C4			1
Pressure Xdcr	PT3-3	C5			1
Pressure Xdcr	PT4-2	C6			1
Temperature	TC1, T	B7	0.5		1
Temperature	TT1-1	C4			1
Temperature	TT1-2	C4			1
Temperature	TT1-3	C5			1
Temperature	TT1-4	C5			1
Temperature	TT1-5	C6			1
Temperature	TT1-6	C4			1
TOC (CO2 Detector)	IG1	C3	1		1
SPA Heater	HT1	C7	1		
IR/GLS Heater	HT2	C4	1		
UV Drive	UV1	C2	1	2	1[2]
Valve, 3-way	TV1-1	B5	1	2[3]	
Valve, 3-way	TV1-4	C7	1	2[3]	
Valve, 3-way	TV1-5	C4	1	2[3]	
Valve, 3-way	TV1-6	C3	1	2[3]	
Valve, 3-way	TV1-9	B6	1	2[3]	
Valve, 3-way	SV1-2	B7	1	2[3]	
Valve, 3-way	SV1-3	B7	1	2[3]	
Valve, 3-way	SV1-4	D4	1	2[3]	
Condensate Detector	CD1	D4	1	1	
Total Channel Counts[1]			19	22	20

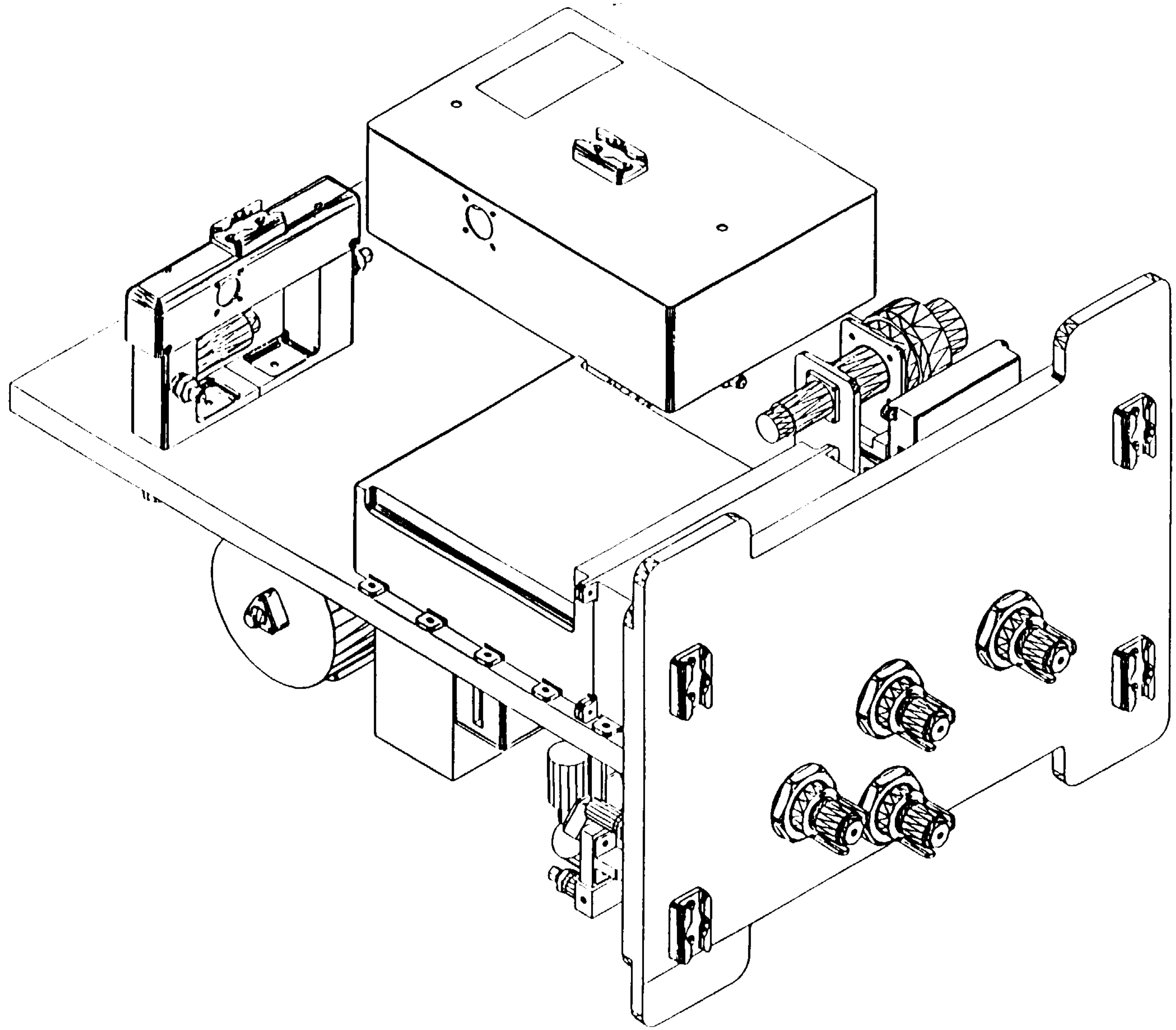
[1] Per Flow Diagram 7330168 Rev. G

[2] not shown in Rev.G. to be added

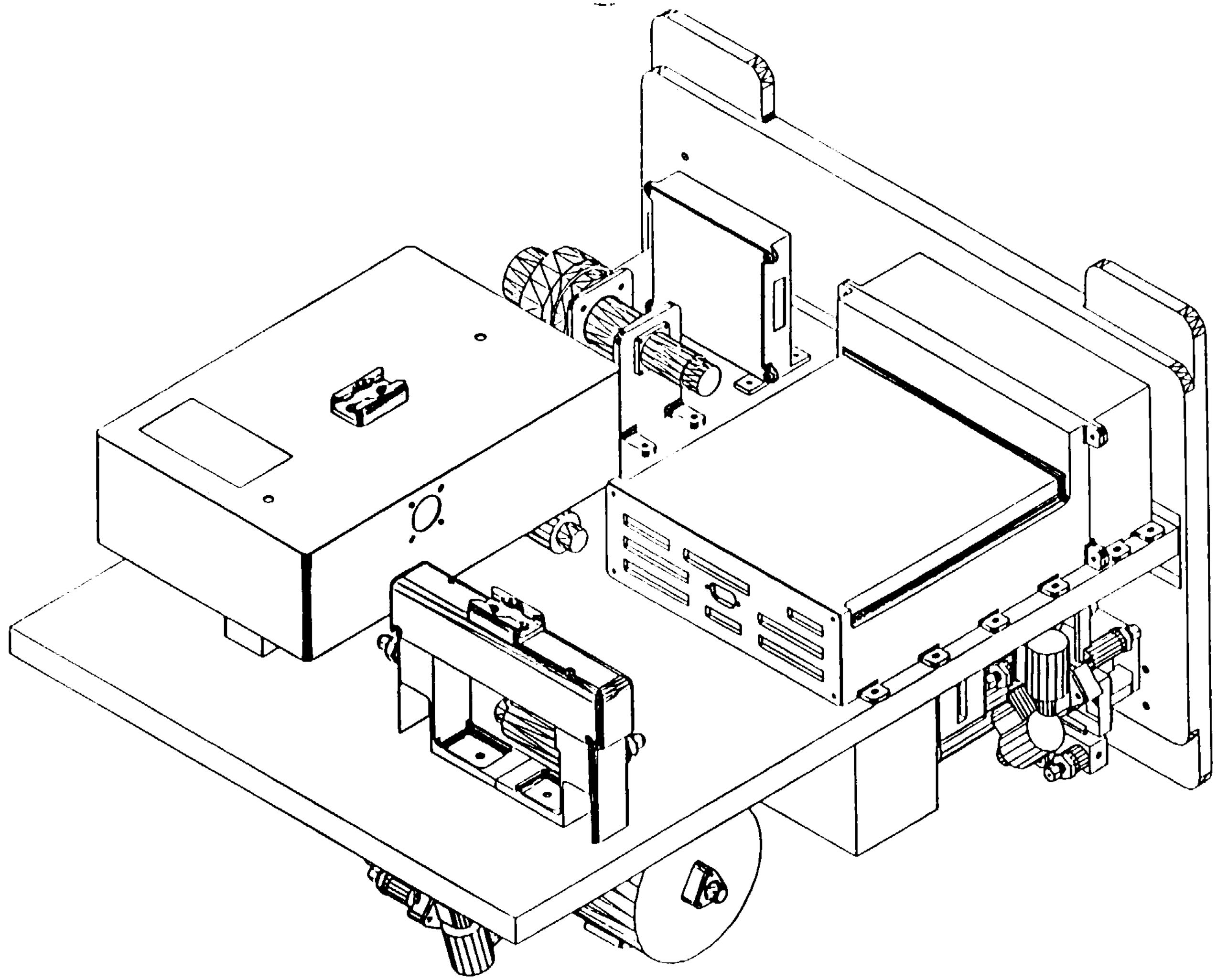
[3] baseline assumes full position mitigation



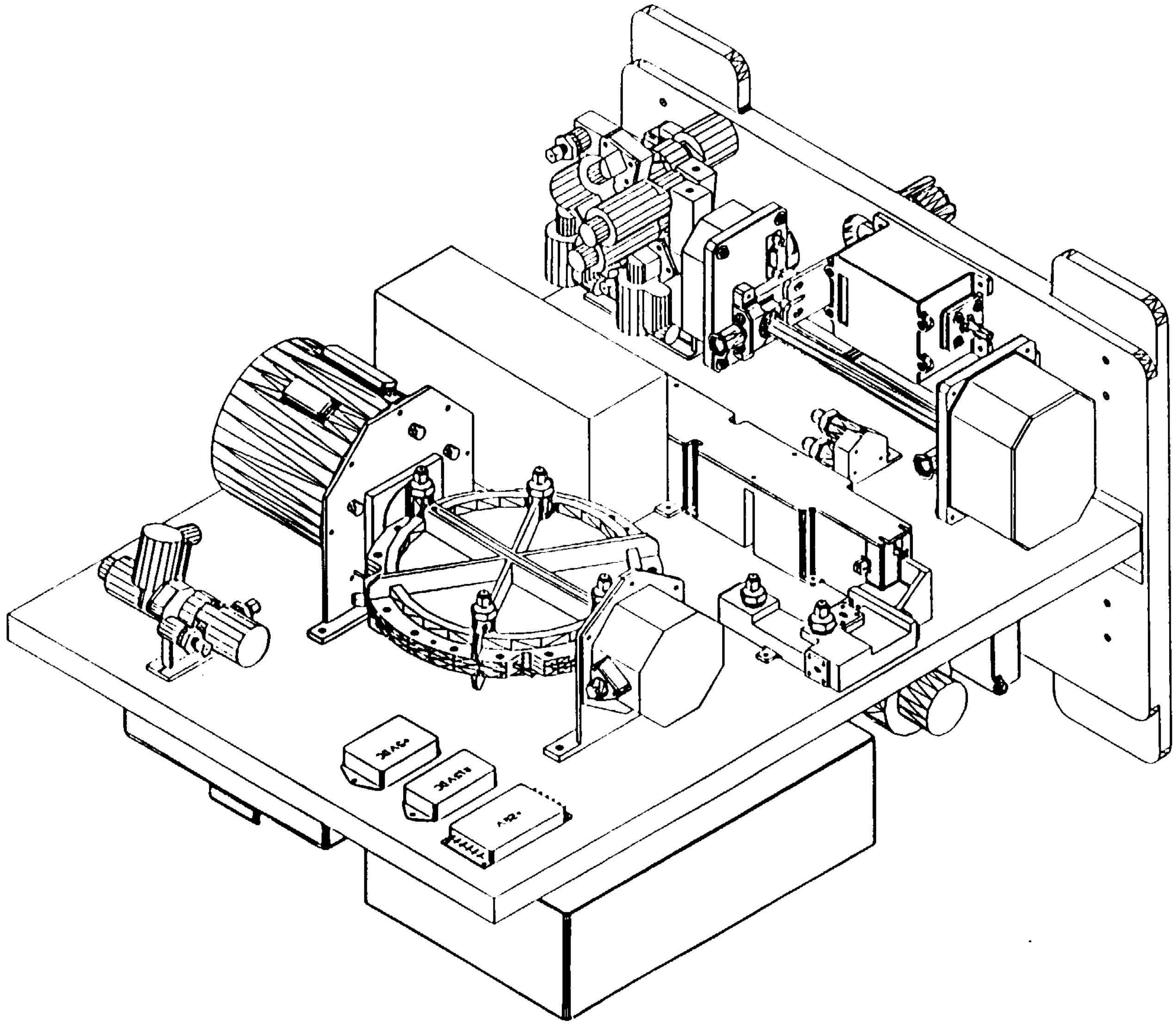
PCWQM Overall Dimensions



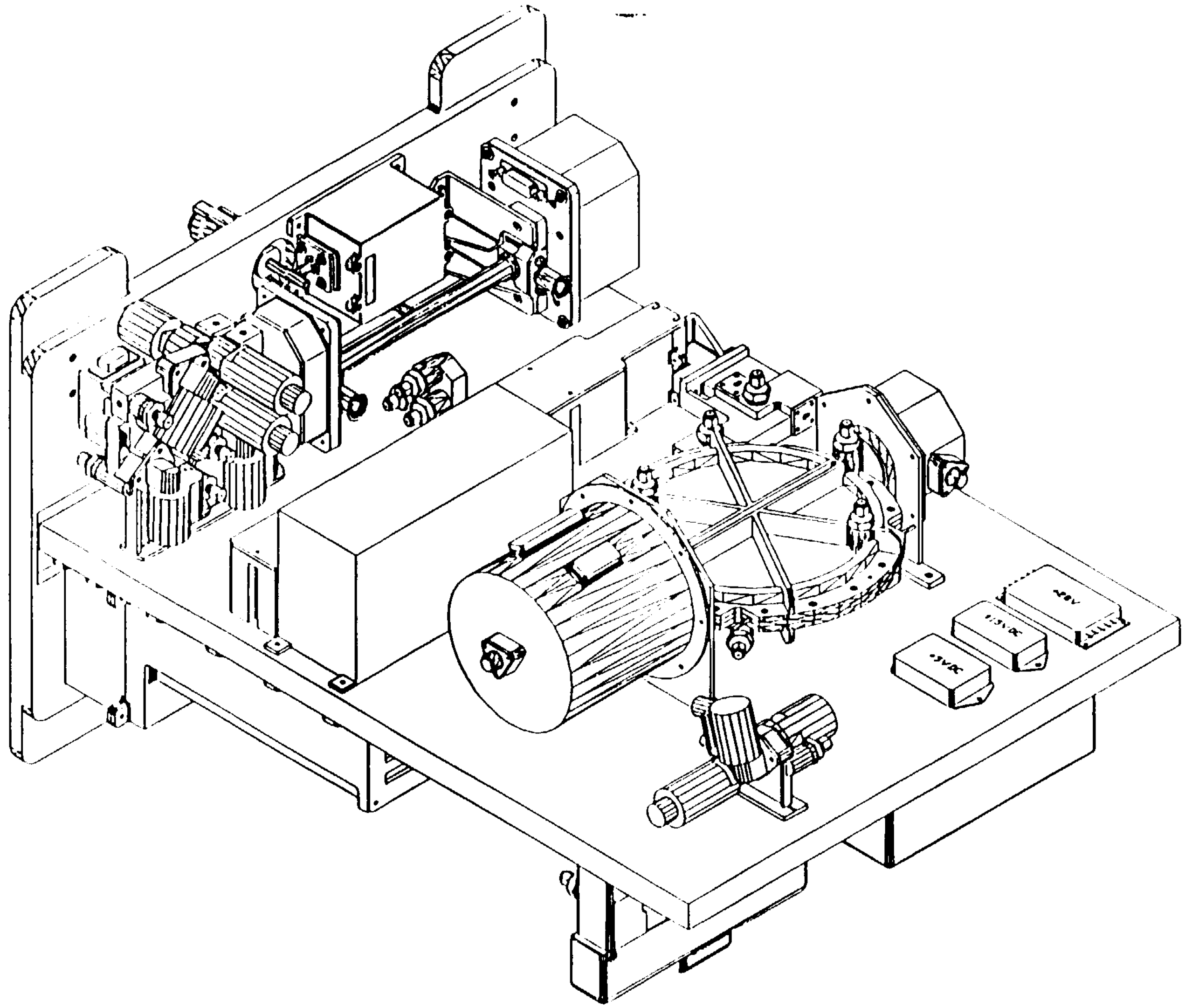
PCWQM Top Front Panel View



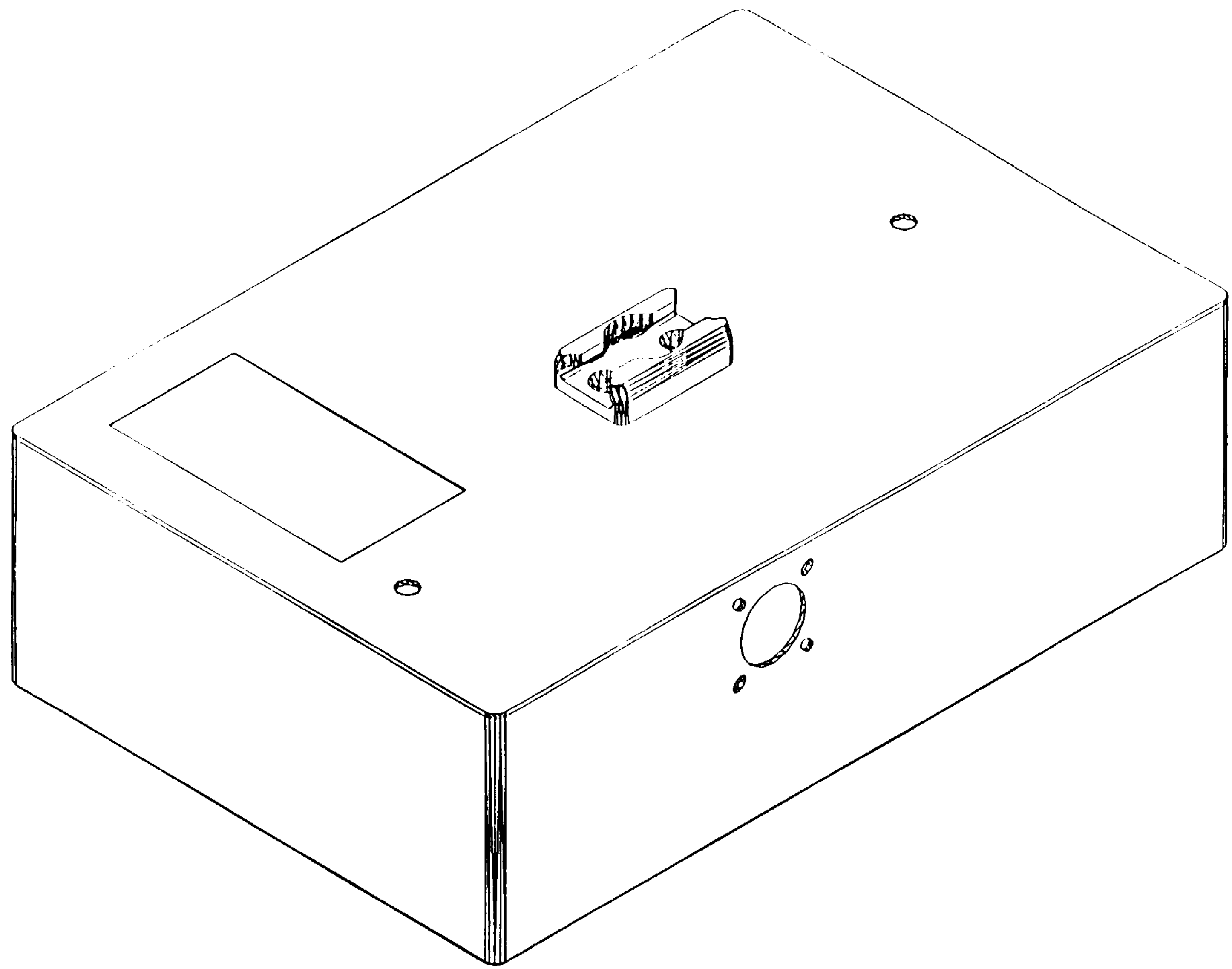
PCWQM Top Rear Panel View



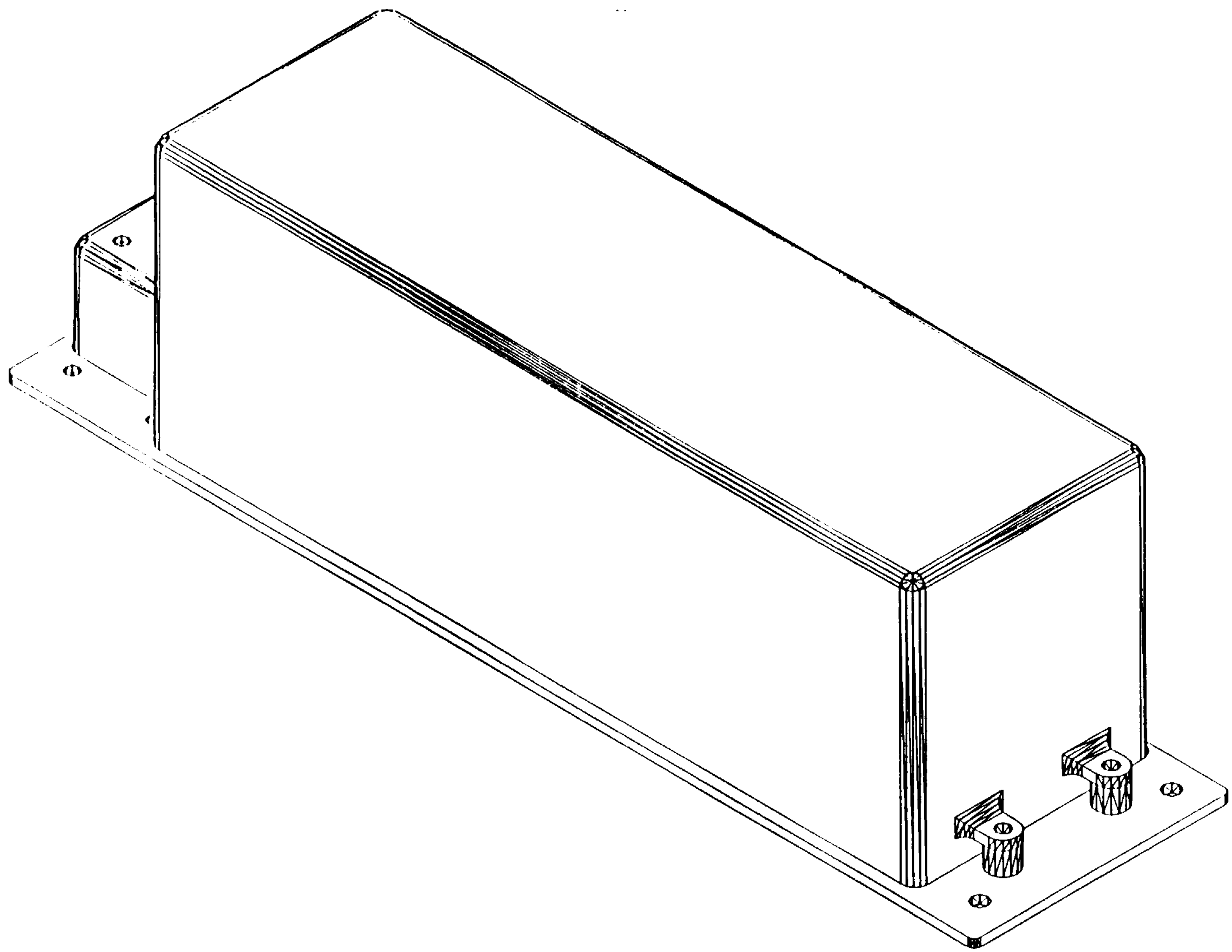
PCWQM Bottom Rear Left Panel View



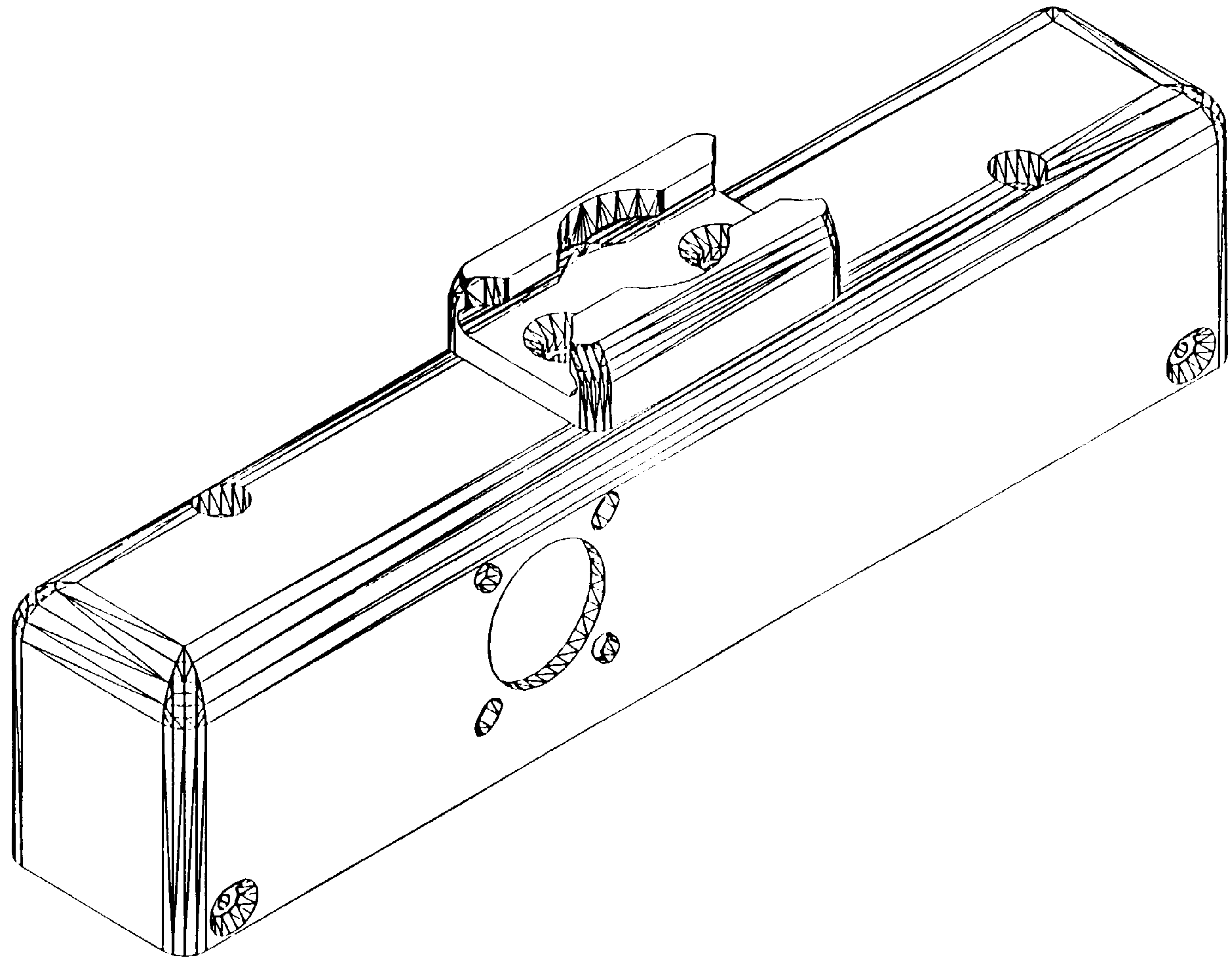
PCWQM Bottom Rear Right Panel View



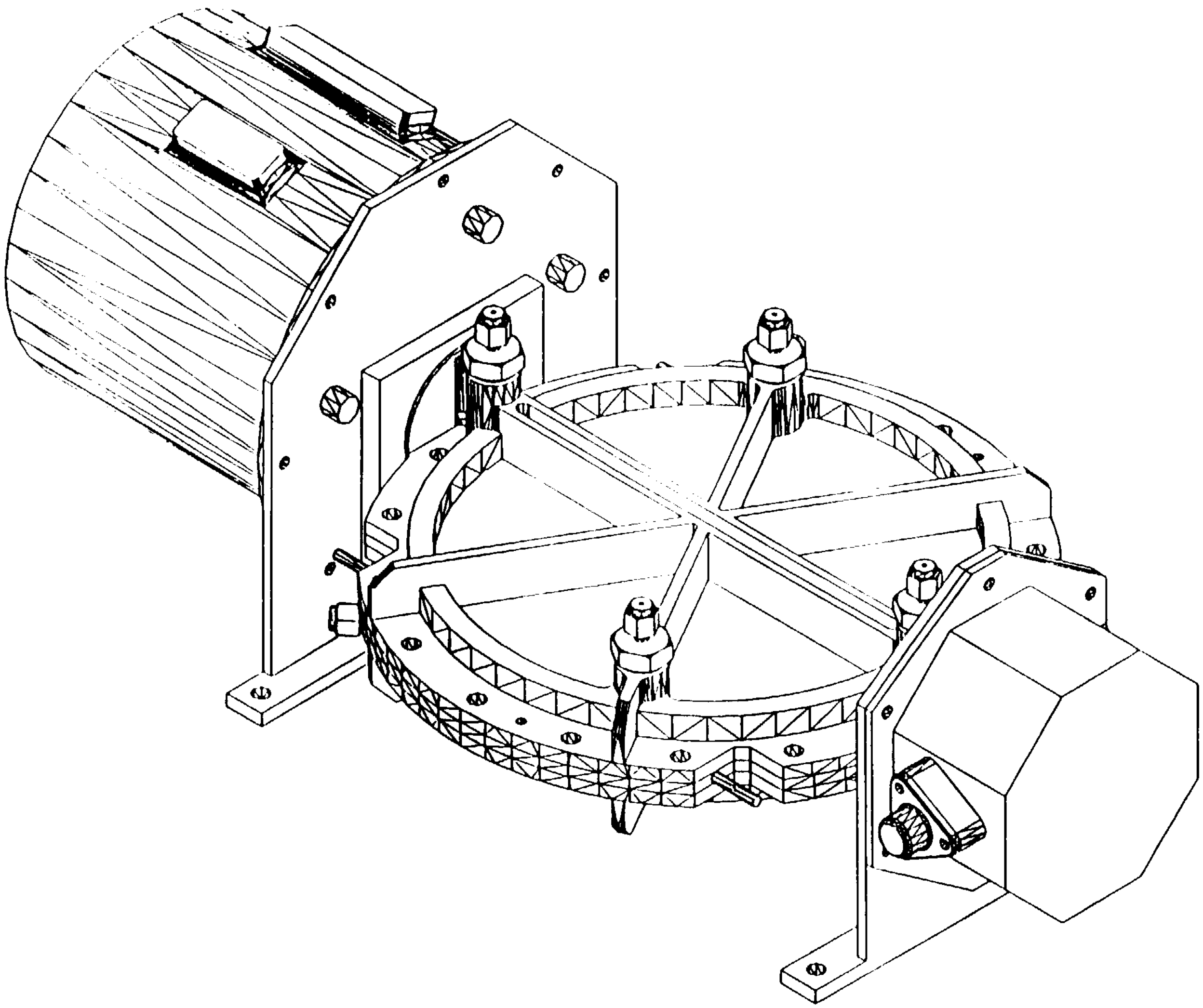
ORU3 = pH and Cal Standard Assembly



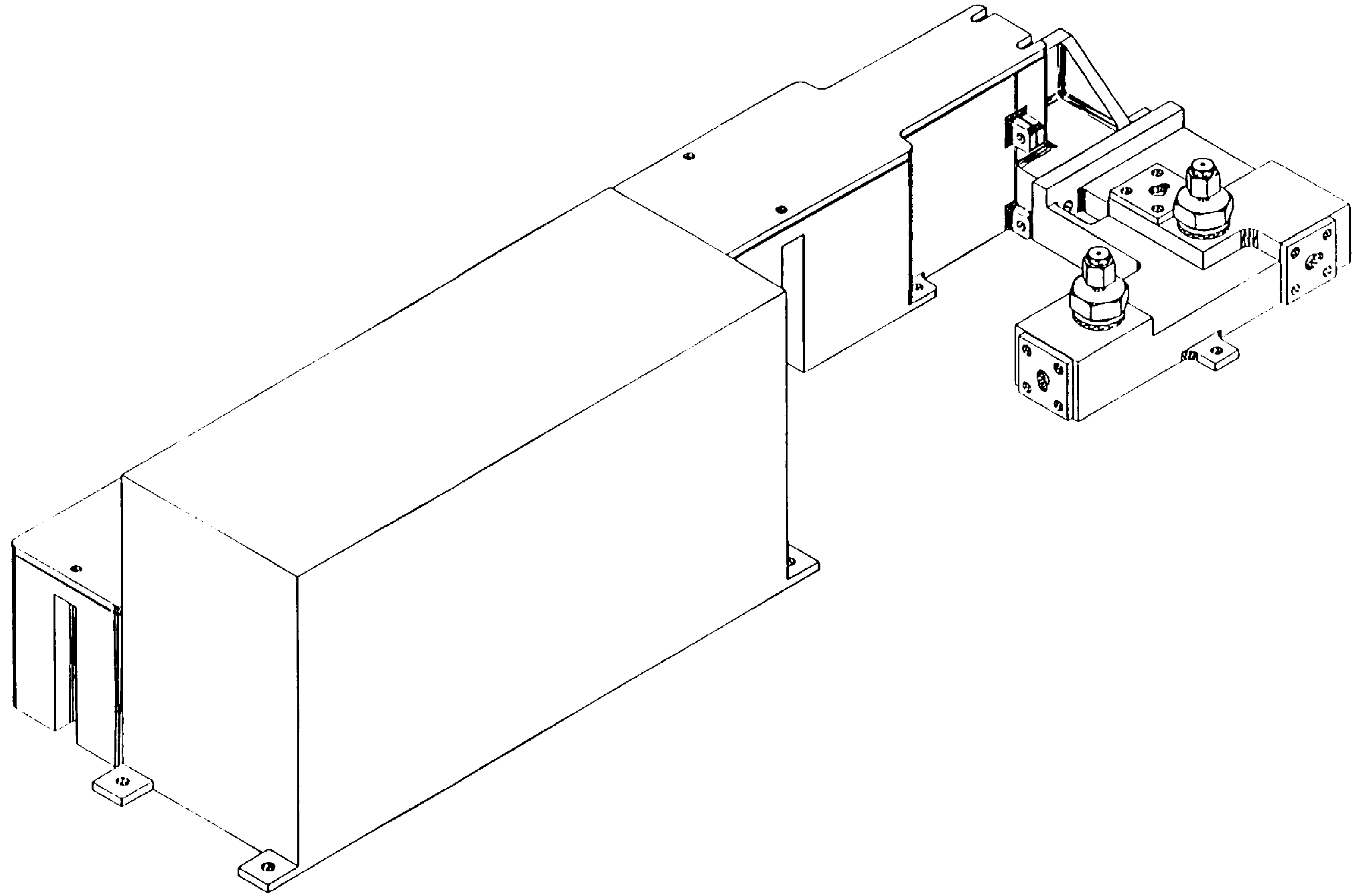
pH Probe and Electronics Assembly



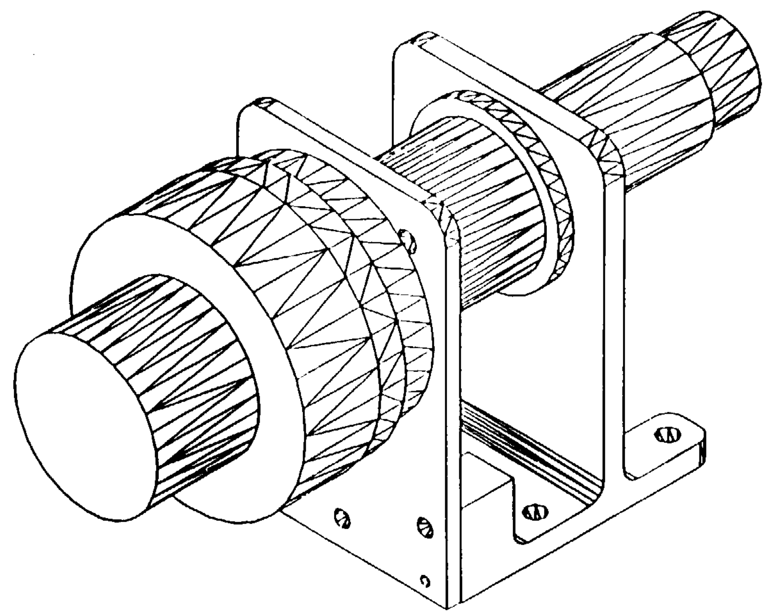
ORU2 = Solid Phase Acidifier Assembly



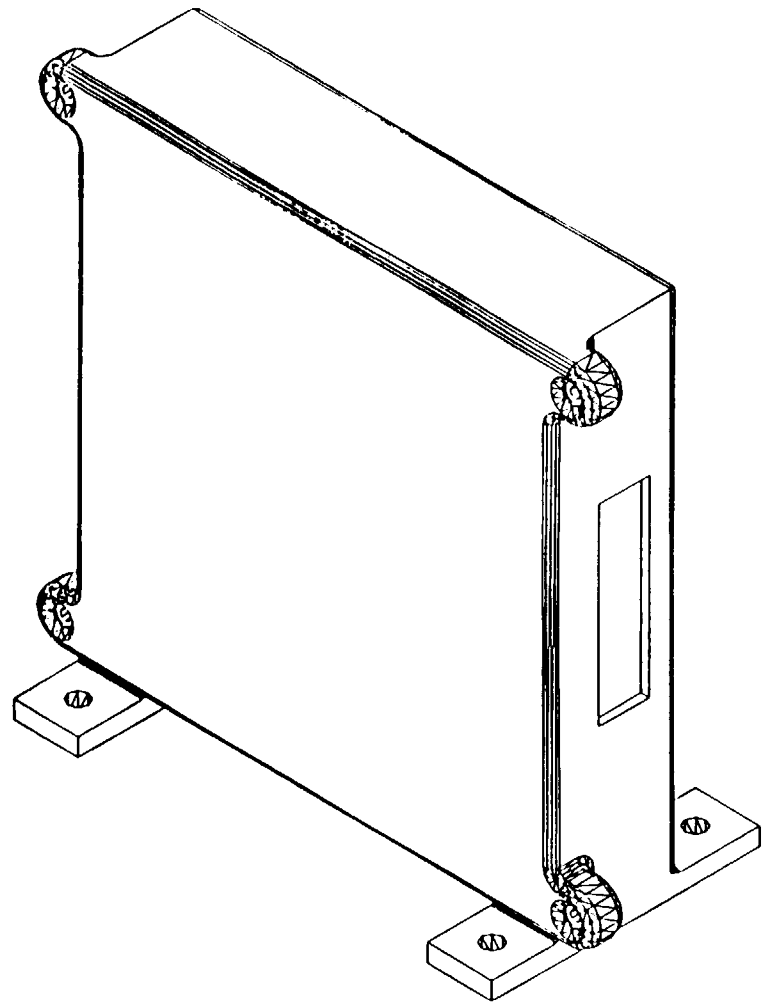
TIC/TOC Detector Assembly



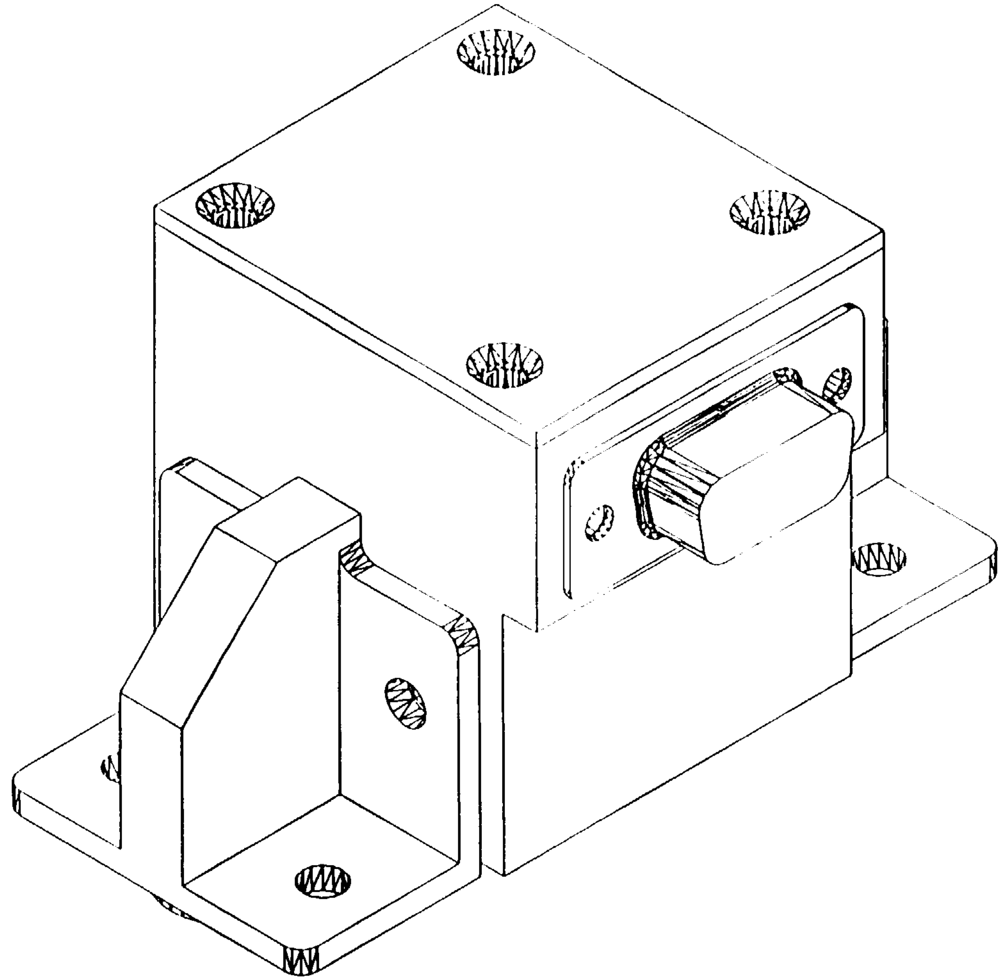
UV Reactor Assembly



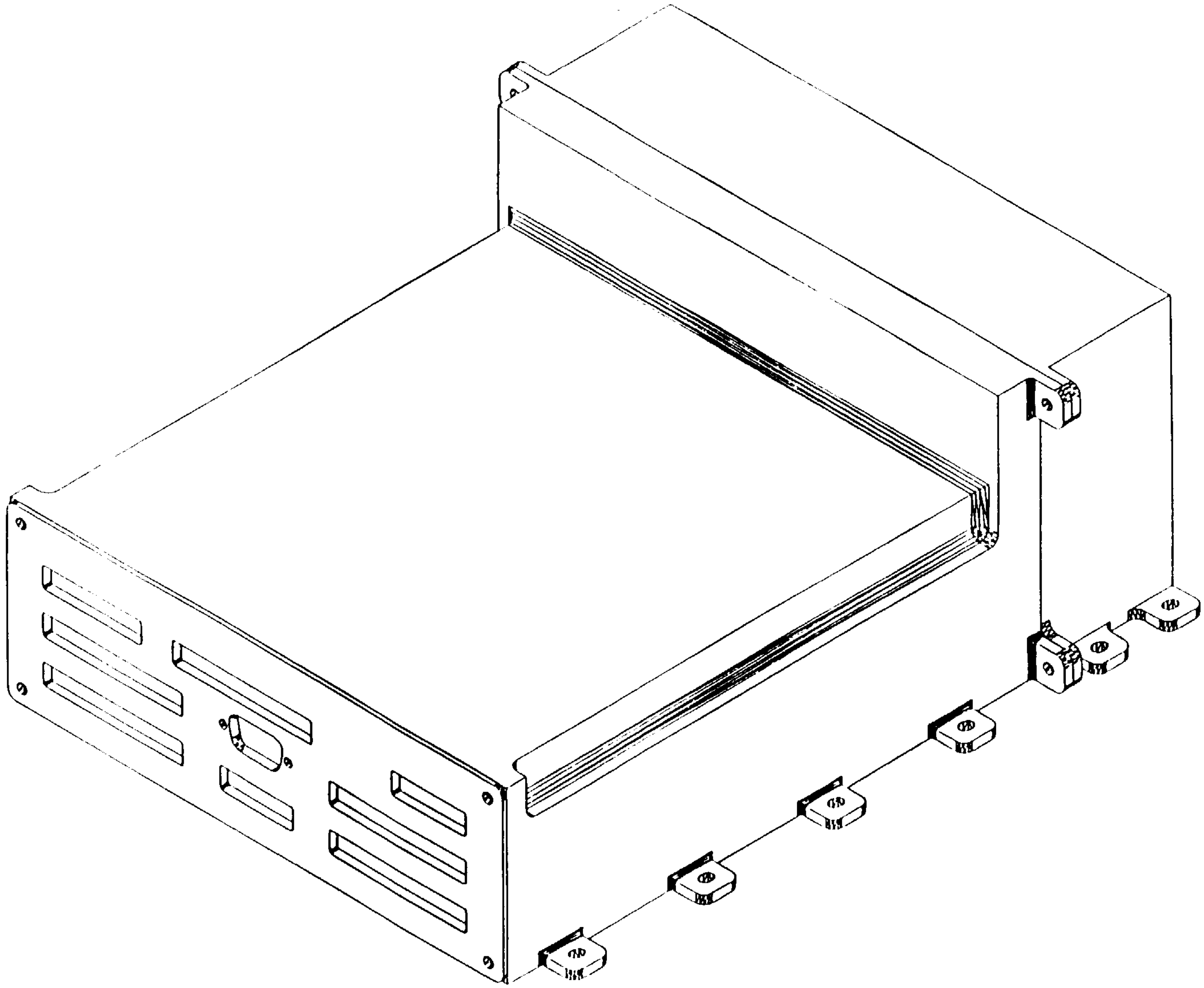
Pump/Motor Assembly



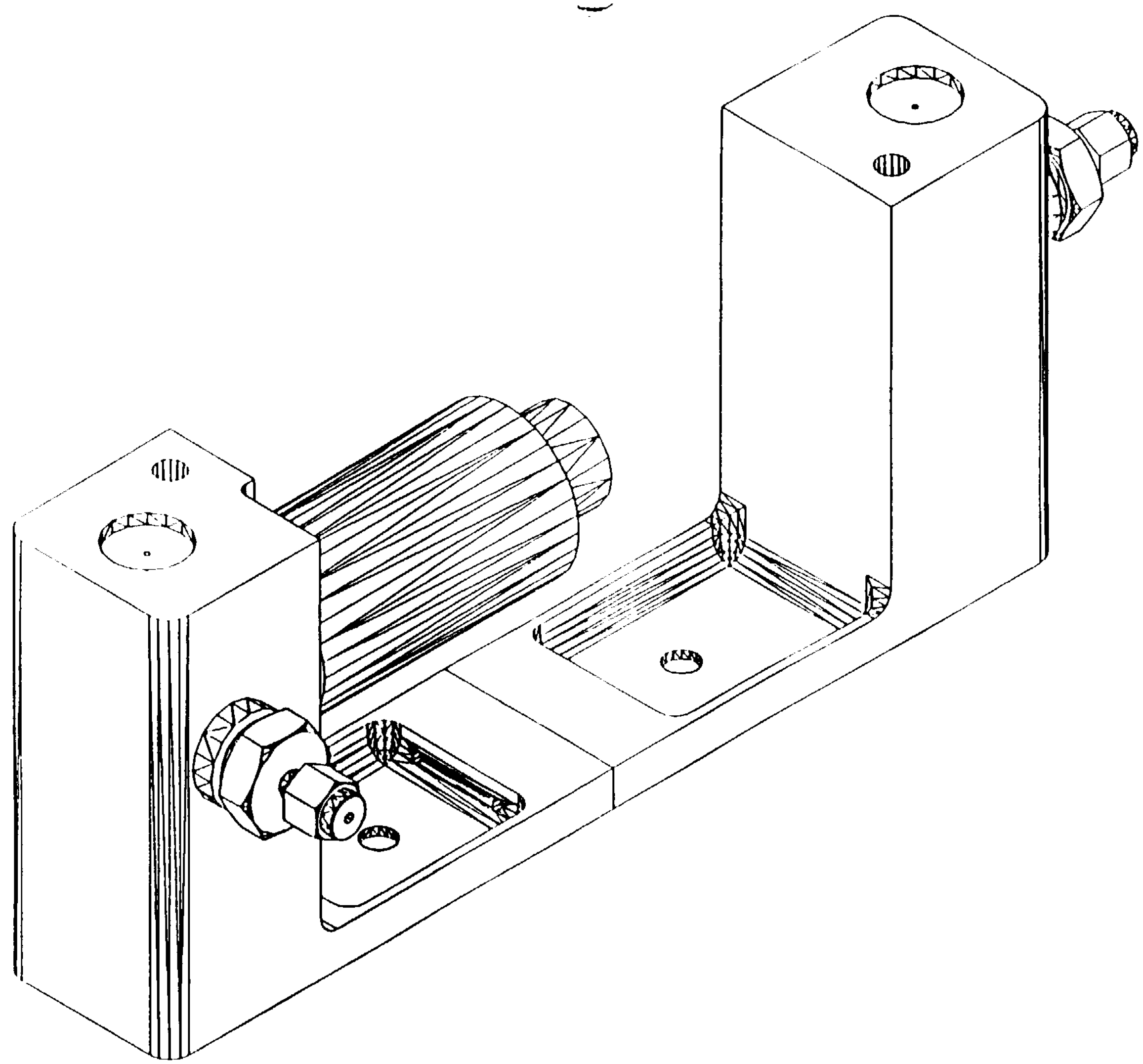
Pump Motor Electronics Assembly



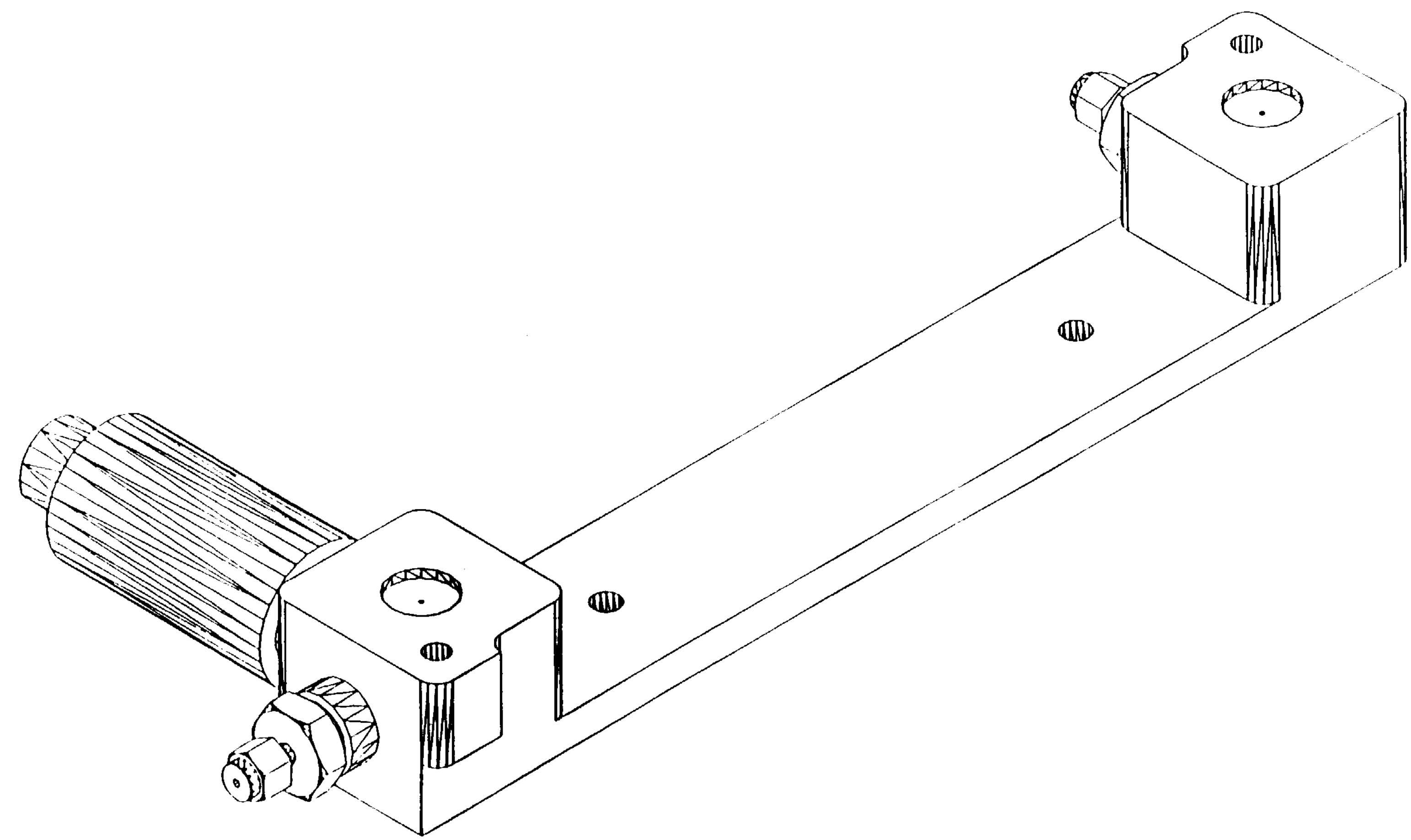
Condensate Detector Assembly



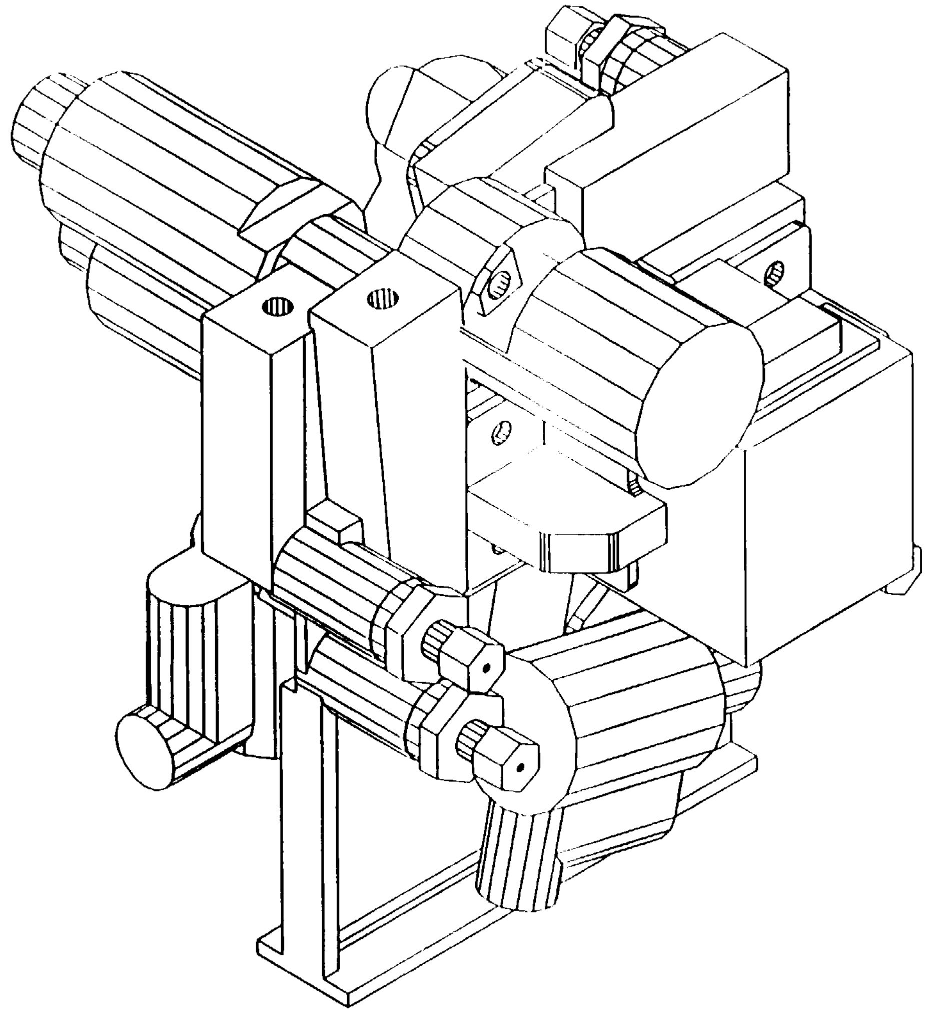
Assumed Firmware Controller Volume



ORU2 Interface Manifold Assembly



ORU3 Interface Manifold Assembly



Oxygen Manifold Assembly

PCWQM Future Technical Development

- Must establish Technical Baseline and Program Requirements!

- This directly impacts Cost & Schedule!

- Examples:
  - Class S -vs- Class B EEE Parts
  - Analyses detail (to what level(s), safety factors, etc.)
  - Testing -vs- Analyses
  - Amount of "Flow down" requirements that would have to be levied on our vendors
  - HSD/DCMO involvement in Assembly and Testing
  - MRB Responsibility