



DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

2

IN REPLY REFER TO:
NAVSEA TASK 91-002/
91-003

AD-A242 554



NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 08-91

EVALUATION OF BAUER K-20 DIESEL POWERED HIGH PRESSURE
BREATHING AIR COMPRESSOR AND THE
P-5 PURIFICATION SYSTEM
(UNMANNED)

GEORGE D. SULLIVAN

AUGUST 1991

DISTRIBUTION STATEMENT A: Approved for public release;
distribution is unlimited.

Submitted:

G.D. SULLIVAN
GS-11
Test Director

Reviewed:

J.W. McCARTHY
QM-14
Hyperbaric Engineer

Approved:

JAMES E. HALWACHS
CDR, U.S. Navy
Commanding Officer

J.B. McDONELL
LCDR, USN
Executive Officer

DTIC
ELECTE
NOV 18 1991
S B D

91-15854



01 1110 000

REPORT DOCUMENTATION PAGE				
1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE			DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NEDU Report #08-91			5. MONITORING ORGANIZATION REPORT NUMBER(S)	
6a. NAME OF PERFORMING ORGANIZ. Navy Experimental Diving Unit		6b. OFFICE SYMBOL (If applicable)		7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Panama City, Florida 32407-5001			7b. ADDRESS (City, State, and ZIP Code)	
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Naval Sea Systems Command		6b. OFFICE SYMBOL (If applicable) OOC		9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Washington, D.C. 20362-5101			10. SOURCE OF FUNDING NUMBERS	
			PROGRAM ELEMENT NO.	PROJECT NO. TASK NO. 91-002 91-003
11. TITLE (Include Security Classification) Evaluation of BAUER K-20 Diesel Powered High Pressure Breathing Air Compressor and the P-5 Purification System.				
12. PERSONAL AUTHOR(S) Mr. David Sullivan				
13a. TYPE OF REPORT FINAL		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year,Month,Day) August 1991
15. PAGE COUNT 27				
16. SUPPLEMENTARY NOTATION				
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP	BAUER K-20 Diesel Powered High Pressure Breathing Air Compressor & P-5 Purification System.	
19. ABSTRACT (Continue on reverse if necessary and identify by block number) In response to NAVSEA tasking, Navy Experimental Diving Unit (NEDU) tested the BAUER K-20 diesel powered high pressure breathing air compressor from 29 May 1991 to 18 June 1991. This test had a twofold purpose (1) to determine if the compressor met military specifications making it suitable for use by the U.S. Navy diving community, (2) to determine if the air purification system, mounted as part of the unit, functioned as specified and was suitable for addition to the Approved for Navy Use (ANU) list.				
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION	
22a. NAME OF RESPONSIBLE INDIVIDUAL		22b. TELEPHONE (Include Area Code)		22c. OFFICE SYMBOL

CONTENTS

	Page No.
I. INTRODUCTION.....	1
II. EQUIPMENT DESCRIPTION.....	1
A. COMPRESSOR.....	1
B. DIESEL ENGINE.....	3
C. INSTRUMENT PANEL.....	3
D. FUEL TANK.....	3
E. PURIFICATION SYSTEM.....	3
F. FRAME.....	3
G. CLUTCH.....	3
H. INTER AND AFTER-COOLERS.....	3
I. OIL/WATER SEPARATOR BLOCK.....	5
J. AIR FLOW.....	5
III. TEST PROCEDURE AND RESULTS.....	7
A. ENDURANCE TEST.....	7
B. CHARGE RATES.....	8
C. OIL CONSUMPTION.....	8
D. AIR SAMPLING.....	9
E. MAINTENANCE.....	9
IV. CONCLUSIONS.....	9
V. REFERENCES.....	10
APPENDIX A - Test Log.....	A-1 thru A-9
APPENDIX B - Air Sample Results.....	B-1 thru B-3

ILLUSTRATIONS

<u>Figure No.</u>		<u>Page No.</u>
1	Compressor Front View	2
2	Compressor Rear View	2
3	Compressor Air Flow Diagram	4
4	Test Configuration	6

Accession For	
NTIS GBA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Availability	
Dist	
A-1	

I. INTRODUCTION

In response to NAVSEA testing¹⁻², the BAUER diesel powered K-20 high pressure, breathing air compressor was tested by NEDU³ to determine if the compressor and purification system would provide suitable breathing air and a service life satisfying U.S. Navy requirements for divers air supply compressors.

There are various methods of testing compressor capacities and suitability, depending on the use requirements. Highly portable, diesel driven divers air compressors are designed to provide high pressure air with relatively low volume outputs. Divers require low pressure air with high volume. The average divers high pressure air compressor is connected to large volume, high pressure air storage flasks to meet this need. In normal operation the high pressure air is reduced to a lower pressure to act as a breathing medium for divers. During use, the pressure gradually reduces in the storage flasks. Accordingly, the compressor tends to run on a continuous basis as the diving day continues since the demand is usually greater than the supply. At the end of the diving day or when air requirements are reduced, the compressor will exceed the demand and fill the air flasks.

For the purposes of this test³, NEDU chose a method consisting of injecting carbon monoxide into the compressor suction (50 PPM) while charging the storage flasks to 2000 psig. The vent was opened to maintain 2000 + psig while the compressor ran continuously. This method closely simulated the operation a compressor would experience in the field. The introduction of carbon monoxide was intentionally excessive for test purposes.

Random charge rates were taken from 1000 to 2000 psig on a daily basis. The compressor was operated a total of 50 hours. Testing included subjective evaluation of the compressor and purification system operation but did not include detailed mechanical review of the individual components of the system.

II. EQUIPMENT DESCRIPTION

The BAUER K-20 high pressure breathing air compressor consists of a K-180 high-pressure compressor driven by a two-cylinder Deutz diesel engine connected by a V-belt drive (Figures 1 and 2). The unit includes an instrument panel, fuel tank, air purification system, and skid-mounted frame. The K-20 is rated to provide 20 cubic feet per minute (cfm) of free air compressed to 5000 pounds per square inch (psi). The unit can be operated in temperatures ranging from -25°F to +125°F.

A. COMPRESSOR

The compressor is a four-cylinder, four-stage, reciprocating, air-cooled unit. The cylinders are arranged in the form of an X. The compressor will deliver 20 cfm of free air compressed to 5000 psig. The fourth stage cylinder is lubricated by means of a force-fed lubrication system while the other cylinders are mist-lubricated. The cylinders of the compressor block, the intermediate coolers, and the after cooler are air-cooled. The compressor is equipped with a cooling fan mounted on the flywheel which moves the cooling air over intercoolers and compressor cylinders.

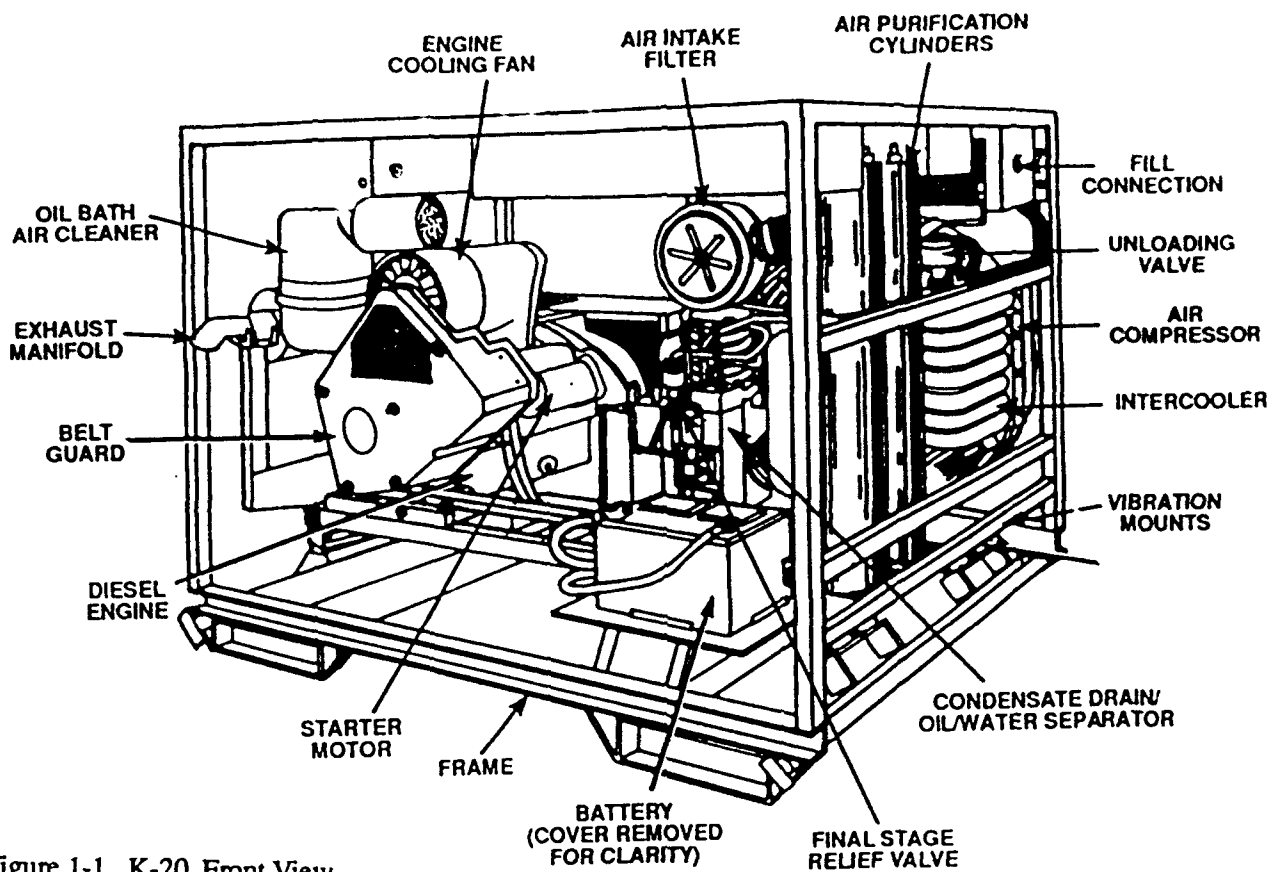


Figure 1-1. K-20, Front View

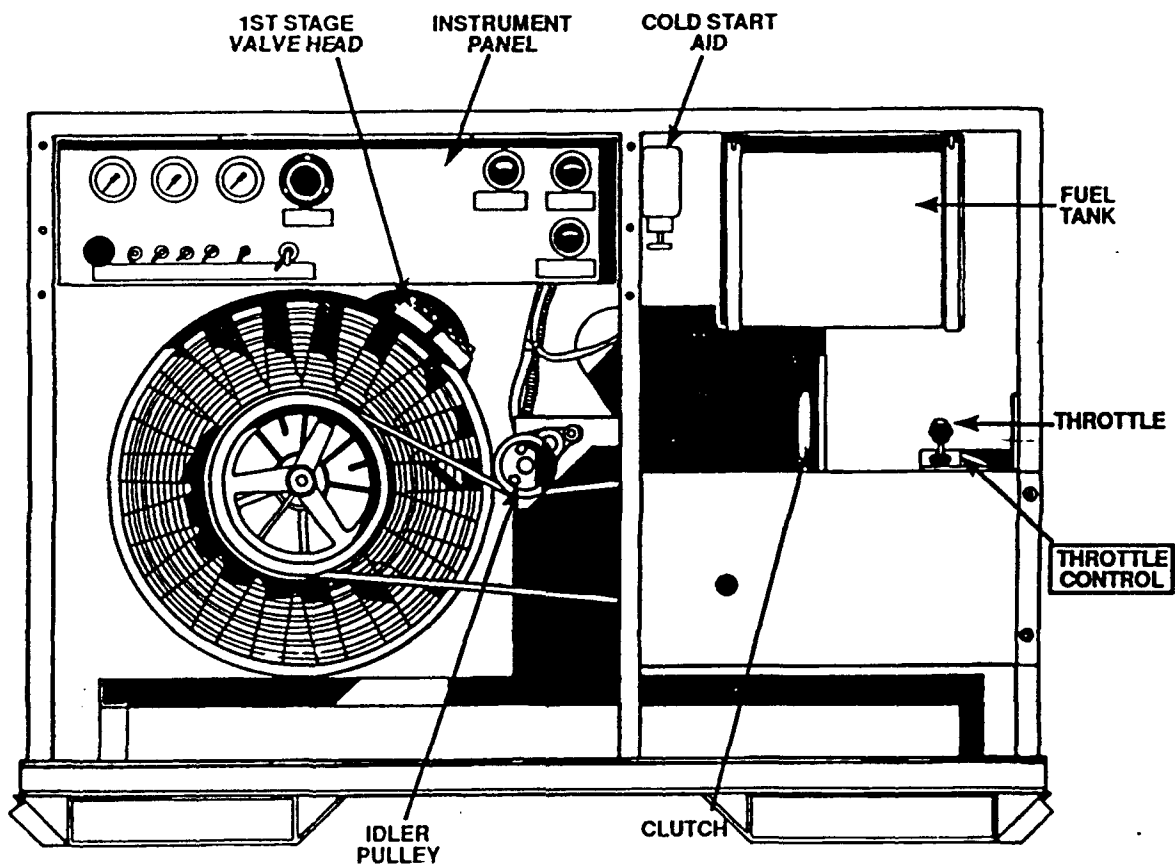


Figure 1-2. K-20, 3/4 Rear View

B. DIESEL ENGINE

The diesel engine develops 27 horse power (hp) at 2200 revolutions per minute (rpm). It is an air cooled, four-cycle, two cylinder, in-line engine and provides rotational torque through a dry plate clutch. The engine can be battery started using a 12-volt system or may be started by use of the provided hand crank.

C. INSTRUMENT PANEL

The instrument panel is located on the front side of the unit, and is mounted on anti-vibration mounts (Figure 1). The rear of the panel is accessible by removing five screws from the back plate.

D. FUEL TANK

The fuel tank is located above the engine, toward the front (Figure 1). It has a 13 gallon capacity with no reserve and is sufficient for eight hours of continuous operation.

E. PURIFICATION SYSTEM

The purification system consists of two purifying cylinders using replaceable cartridges (Figure 3). The upstream chamber has a molecular sieve using Bauer cartridge No. 058825. The downstream chamber has a molecular sieve and hopcalite using Bauer cartridge No. 068416. The molecular sieve absorbs oil and water vapors. The hopcalite converts carbon monoxide (CO) to carbon dioxide (CO₂). The system is rated by the manufacturer to process a total of 139,500 cubic feet of free air. MIL-C-52973A⁴ requires a maximum of 80 hours between cartridge changes. This compressor is rated at approximately 20 cubic feet per minute, so 80 hours of operation equals 96,000 cubic feet. This equates to 69% of the expected life of the cartridges, allowing a safety margin of 31%.

F. FRAME

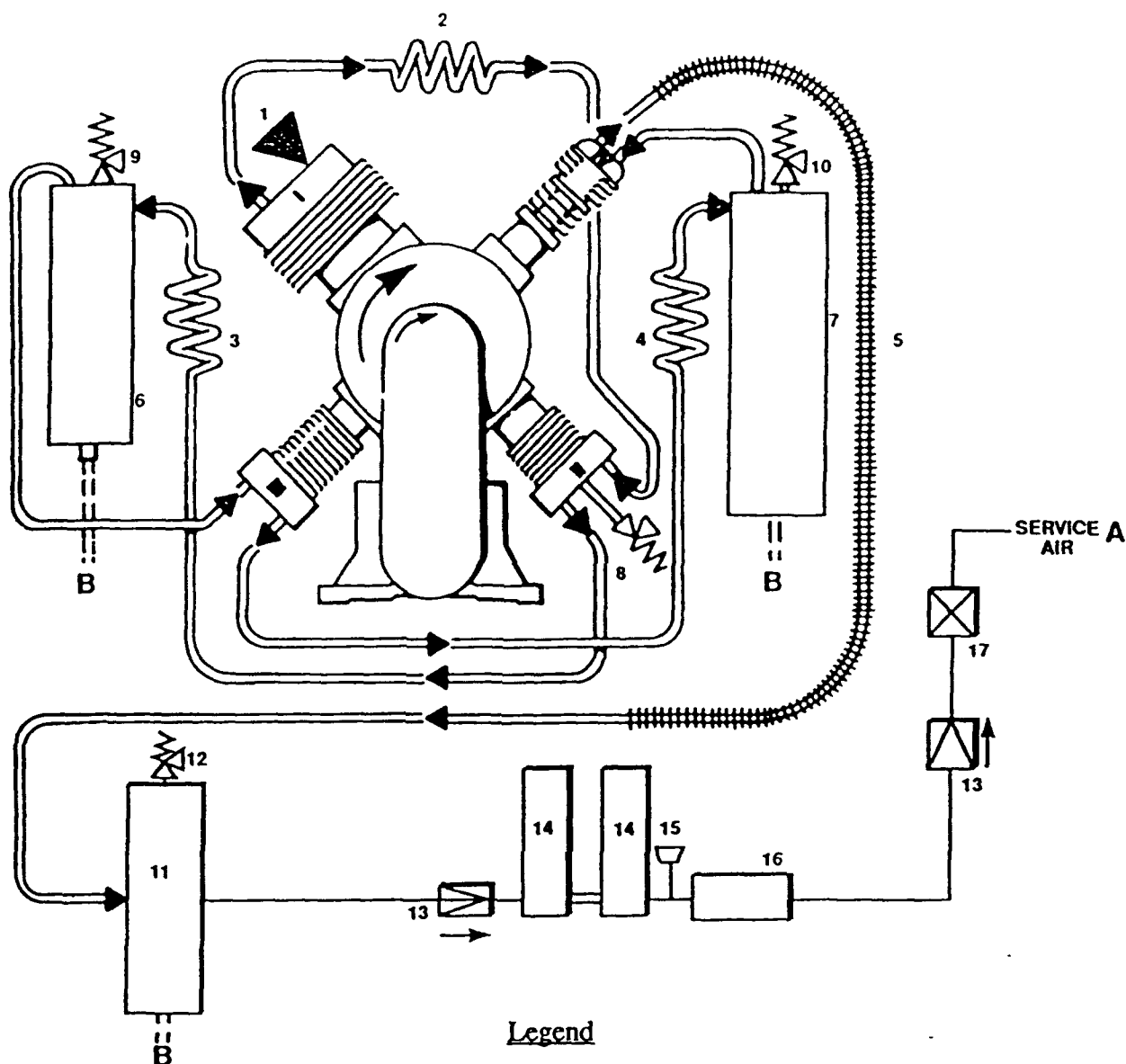
The frame is constructed of welded steel channels. Integrated into the frame design are skids and slinging/tie-down attachments. The subframe is attached to the main frame by 10 anti-vibration mounts.

G. CLUTCH

The dry plate clutch is operated by a hand lever. Disengaging the clutch enables the engine to be started without the compressor.

H. INTER AND AFTER-COOLERS

The inter and after-cooler are circular piping arrays mounted next to the cooling fan which cools the compressed air between the 1st, 2nd and 3rd compressor stages and after the fourth stage.



1. Intake Filter
2. Intercooler (1st stage)
3. Intercooler (2nd stage)
4. Intercooler (3rd stage)
5. After Cooler
6. Condensate Block (2nd/3rd stage)
7. Interfilter (3rd/4th stage)
8. Interm. Pressure Safety Valve (1st stage)

9. Interm. Pressure Safety Valve (2nd stage)
10. Interm. Pressure Safety Valve (3rd stage)
11. Condensate Block (4th stage)
12. Final Pressure Relief
13. One-Way Valve
14. Filters
15. Bleed Off Valve
16. Pressure Maintaining Valve
17. Service Valve

A Air Outlet

B Condensate Outlet

Note: Condensate Blocks 6, 7, and 11 are actually mounted on a heated condensate drain manifold along with the final separator.

Figure 3. Compressor Air Flow Diagram

I. OIL/WATER SEPARATOR BLOCK

The oil/water separator block used on the K-180 compressor is almost identical to its commercial version. As tested, it incorporates a shatterproof condensate drain coil, O-rings manufactured of Buna-N rubber vice Viton, and the sinter filters have been removed. Installing Buna-N O-rings and removing the sinter filter decreased operating temperature range to -25°F , increasing the overall operating temperature range.

Air passes through three oil/water separators from the second, third and final stages, respectively. The separated oil/water is maintained in the separator blocks until the condensate drain is activated. Power is momentarily interrupted by the condensate drain switch and allows the piston seal to release the second stage air pressure to the atmosphere. The pressure release allows the second, third, and final condensate valve block seats to lift. The oil/water condensate then vents through the condensate drain valves, past the drain valve seats and back to the drain passage in the lower condensate block, and vents directly to the atmosphere. The condensate heater is used in cold weather operations to prevent condensate from the second, third, and final stages from freezing. The use of the condensate heater is not required below 32°F due to low relative humidity and the fast-moving air within the separator block. However, slow draining or visible freezing of the condensate during colder weather may warrant the use of the condensate heater. The condensate heater draws 200 watts of power and should be turned on only after the unit is operational.

J. AIR FLOW

The first stage (I) of the compressor draws in atmospheric air through a micron intake filter (1). The air is compressed to a pressure of about 45 psi. The compressed air entering the second stage (II) is re-cooled by the intercooler (2), then further compressed to about 230 psi and passed through the intercooler (3) and inter-filter (6) to the third stage (III). In the third stage, the air is compressed to 1000 to 1100 psi. Leaving the third stage, the air passes through intercooler (4) and inter-filter (7) to the fourth stage (IV) where it is compressed to operating pressure. Exiting the fourth stage, the air is passed through the after cooler (5) and is routed via connection A to the unit's filter system. The intermediate pressures of the individual stages are monitored by the intermediate pressure safety valves and service line pressure gauge. Final pressure is monitored by the final pressure safety valve. Condensate can be manually drained by a switch on the instrument panel. Upon shutdown, the condensate automatically drains.

A pressure maintaining non-return valve is provided down stream from the filter system to ensure that pressure build up occurs in the filters during start up and initial compressor air delivery. This provides for continuous optimum filtering, moisture separation and prevents backflow of compressed air from the charged air storage tanks when the compressor is secured. All four stages of the compressor are protected by safety relief valves.

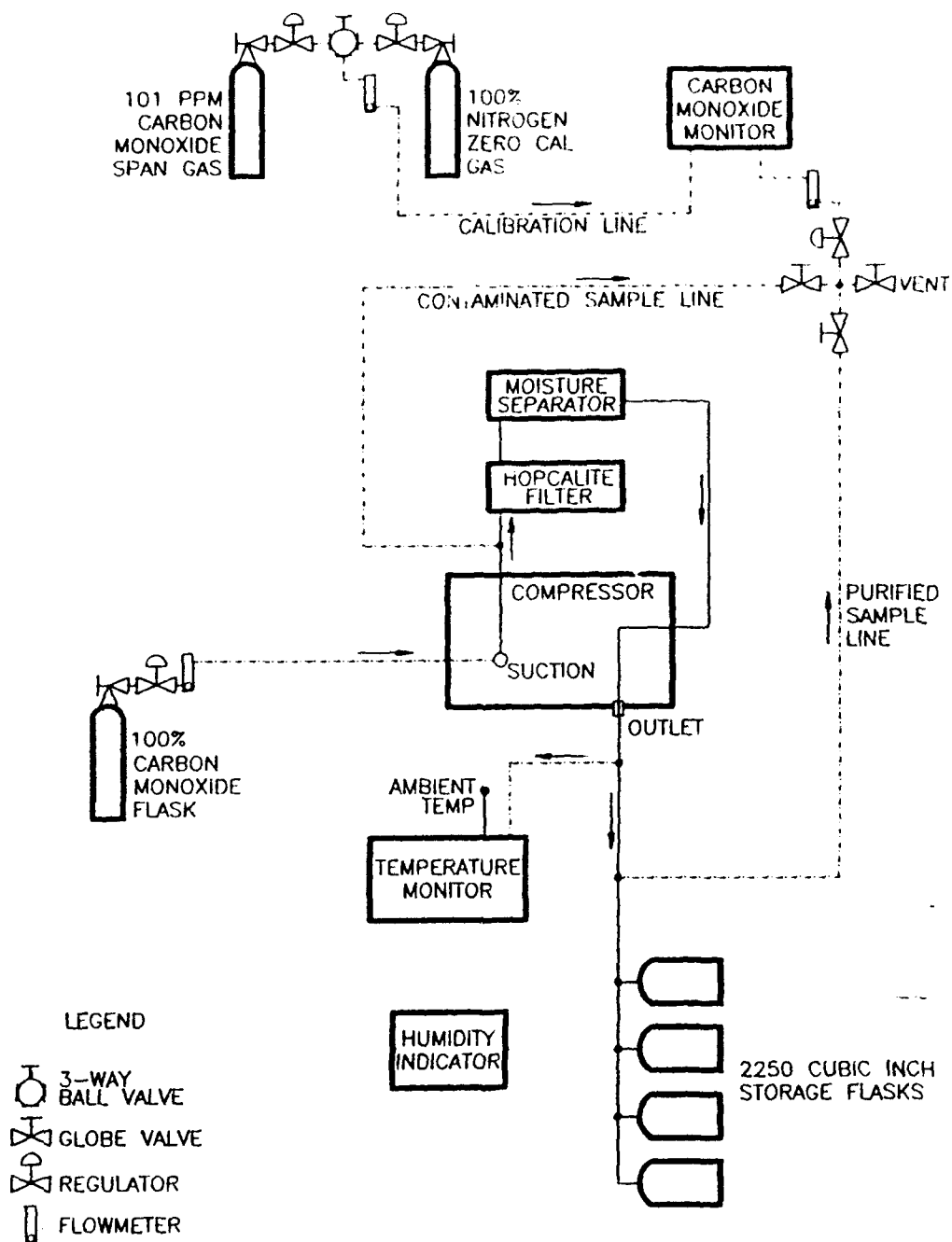


FIGURE 4
NEDU TEST NO. 91-17 TEST CONFIGURATION

III. TEST PROCEDURE AND RESULTS

The compressor unit and ancillary equipment were set up in accordance with the NEDU test plan³ and the K-20 Compressor maintenance manual⁵. A line diagram of the test configuration is depicted in Figure 4. The unit was placed in an exterior work area, open to ambient temperature but protected by an awning from direct weather. A Digitech HT series, model 5820 temperature monitor and two Yellow Springs Instruments 700 series thermistor probes were attached to measure compressor discharge and ambient temperatures. An Ideal humidity indicator, model 3310-20 was mounted near the compressor unit and the humidity was recorded. An MSA Toxgard carbon monoxide monitor with a flow range from 350 to 900 cc per minute, was used to analyze compressor discharge air samples before and after the purification system. 100% Nitrogen (N₂) and 101 parts per million (ppm) carbon monoxide (CO) in air were used to calibrate the monitor on a daily basis. The gases were fed through a Victor Equip Co. 4000 psig manual regulator to a Fischer and Porter flow meter and into the monitor sensor. Carbon monoxide was introduced directly into the compressor air intake through a Victor Equip Co. 4000 psig manual regulator and Fischer and Porter flow meter. The introduction of CO was adjusted to maintain 50 ppm of CO at the entrance of the filtration system. Appendix A is the test log and contains the recorded data.

The K-20 Compressor Maintenance Manual⁵ was used to conduct an initial receipt inspection of the equipment to ensure all parts and material were received. All instruments and controls were clearly and permanently marked and easily viewed by the operator. The final air pressure gauge had lost approximately half of its liquid and the service line air pressure gauge had lost all of its liquid. The exhaust was leaking between the manifold and the muffler. All drains functioned properly. The manufacturer provides a discharge pipe to direct the water and oil spray blow down from the separators away from the operator's feet. A seven foot section of hose was attached to the pipe and placed to the downwind side of the unit to further distance the spray.

A. ENDURANCE TEST

The compressor was operated for a one hour no load test prior to starting the actual 50 hour test. No load conditions consisted of the vents open and the back pressure valve set at 2000 psig. An air sample was taken at one hour.

After the first five hours of operation the unit was secured with 2500 psi in the volume tanks. All vents, flowmeters, and blowdown valves were closed. The unit remained secured until 0600 the following day. The pressure drop was less than 180 psig, and was considered insignificant when temperature differentials were calculated.

The compressor was operated daily to charge four 2250 cubic inch (floodable volume) cylinders. The four cylinders were interconnected, simulating one large air flask. When 2000 psig flask pressure was obtained the compressor's vent was adjusted to maintain a 2000 psig load during continuous operation.

The charge rate was verified by charging from 1000 to 2000 psig. Carbon monoxide was introduced into the air suction at the rate of 50 to 100 ppm. Throughout the 50 hours of testing the compressor discharge was continuously analyzed. Samples were taken before and after the purification system. These readings are located in Appendix B. A total of 50 hours of operation were logged. The following parameters were recorded:

- | | |
|-----------------------------|-----------------------------------|
| (1) Date | (10) Compressor oil pressure |
| (2) Time | (11) Final air pressure |
| (3) Total meter hours | (12) Service line air pressure |
| (4) Total test hours | (13) Service line air temperature |
| (5) Ambient Humidity | (14) CO before filter |
| (6) Ambient Temperature | (15) CO after filter |
| (7) Engine oil pressure | (16) Oil and Fuel Use |
| (8) Engine head temperature | (17) Compressor Capacity |
| (9) Amperage | |

B. CHARGE RATES

The volume of air delivered and the time to achieve that volume was logged daily and is provided in Appendix A. The data collected provided a complete operational and maintenance log for this test and was the basis for computing and evaluating all the test results. Compressor capacity charge rates for the test were as follows and are considered acceptable:

TIME	TOTAL VOLUME	CHARGE RATE
MINIMUM: 15 MINUTES 51 SECONDS	359 CUBIC FEET	23.18 CFM
MAXIMUM: 14 MINUTES 55 SECONDS	359 CUBIC FEET	24.71 CFM
AVERAGE: 15 MINUTES 03 SECONDS	359 CUBIC FEET	23.92 CFM

NOTE: Differences in maximum and minimum delivery rates were the result of the differences in the ambient temperature and humidity at the time recorded. The manufacturer advertises a free air charge rate of 20 CFM, these differences are not considered significant. The majority of temperature differentials between ambient and compressor discharge temperatures were 8 to 12 degrees Fahrenheit. The maximum recorded differential temperature was taken immediately after startup. It is not considered to be a true reading due to the chilling effect caused by the expansion of the compressed air dumping from a relatively high pressure (2000 psig) in the filter housing to a lower pressure in the empty storage flasks.

C. OIL CONSUMPTION

Prior to beginning the test, the oil sumps in the compressor and engine were measured full on the dip stick. An engine oil change using 9250 was completed at 48 hours measured on the total hour meter per the technical manual. Compressor and engine oil levels were checked each morning. The sight glass was checked for bubbles each time the moisture separator blowdown was activated. The compressor oil was changed at 25 hours (prior to receipt at NEDU). Oil consumption was considered acceptable.

D. AIR SAMPLING

Air samples were taken from the compressor purification system discharge at test hours 1, 25 and 50 and sent to the NCSC Laboratory, Code 5130, for purity analysis. Results are attached as Appendix B. All samples were within established limits⁶.

E. MAINTENANCE

Normal routine maintenance was performed at scheduled times. Unscheduled corrective maintenance action performed consisted of the following:

At 9 test hours the unit was secured, the idler pulley had become loose and had to be tightened, and the belts reinstalled on the flywheel. At 18 hours 5 minutes test hours the idler pulley was removed and taken to the NEDU machine shop for overhaul. New holes were bored and tapped and a dog ear with three adjustment holes welded to the idler bracket for additional support. During this time the operator conducted the 50 hour oil change. The engine oil drain plug could not be removed by normal means. The inspection plate was removed and taken to the NEDU machine shop. The existing drain plug was drilled and tapped and a smaller plug threaded into the new hole. A consocko gasket was installed between the inspection plate and the oil pan.

At 33 hours 30 minutes test hours a 21 minute charge rate was recorded. This excessive time prompted the operator to investigate for air leaks. An oil mist revealed a crack in the third stage cylinder. Bauer Compressors, Inc. was contacted. They contracted a Pneumatic Systems Company representative to reported to NEDU to effect necessary repairs. The third stage cylinder was replaced and new piston rings installed. One pint of 2190 TEP was added to the compressor to bring the sump up to operating level. A total of 30 minutes were used to run the compressor for testing after repairs were made. Repairs were completed and the test continued from 34 hours 30 minutes. The BAUER K-180 Instruction Manual⁷ was used as a guide.

IV. CONCLUSIONS

1. The BAUER K-20 compressor delivers acceptable breathing air at a capacity which exceeds the manufacture's specifications.

2. The BAUER P-5 Purification System removes carbon monoxide from contaminated air sources and delivers air of a quality that exceeds required purity standards⁶.

3. Equipment tested by NEDU should be received in the same mechanical condition as a unit delivered to a remote Fleet unit. It should not require any repairs or alterations. Some mechanical deficiencies were encountered as listed above and previously in the body of the report. It is felt these problems are reason not to approve this compressor for ANU list at this time.

V. REFERENCES

1. NAVSEA Task 91-003; Testing of commercially available air compressors for divers use for ANU list.
2. NAVSEA Task 91-002; Testing of air purification systems.
3. NEDU Test Plan No. 91-17 Bauer K-20 Diesel Drive High Pressure Air Compressor and Molecular Sieve (058825)/Hopcalite (068416) Cartridge purification system Evaluation.
4. MIL-C-52973A(ME) Military Specification Compressor Unit, 20 CFM, 5000 psi, Diesel Engine Drive.
5. Operator, Unit and Intermediate (Direct Support/General Support) Maintenance Manual for Bauer K-20, 20 CFM Compressor Diving Air Technical Manual No.5-4310-389-14 Headquarters Department of the Army Washington D.C. 23 October 1990.
6. U.S. Navy Diving Manual, Vol. 1, NAVSEA 0994-LP-001-9010, Air Purity Standards revision 2 December 15 1988 Para 5.3.2..
7. Bauer Instruction Manual High Pressure Compressor Block K-180 BAUER Compressor Inc. 1326 Azalia Garden Road Norfolk Va 23502.

APPENDIX A TEST LOG

[illegible]

COMMENTS

COMPLETED TEST RUN AND CHECKED THE SYSTEM FOR LEAKS. INSTALLED NEW CARTRIDGES IN BOTH CHAMBERS AT 30.5 HOURS ON THE COMPRESSOR METER. DURING THE TEST RUN, CO LEVEL ENTERING THE FIRST FILTER WAS IN EXCESS OF 200 PPM. IT WAS DETERMINED THAT EVEN THOUGH THE COMPRESSOR SUCTION WAS LOCATED WELL UPWIND OF THE DIESEL EXHAUST, THE WIND SHIFTS WERE ENOUGH TO ALLOW EXHAUST FUMES TO ENTER THE COMPRESSOR SUCTION. A 50 FOOT LENGTH OF DRYER EXHAUST HOSE WAS ADDED TO MOVE THE COMPRESSOR SUCTION FURTHER FROM THE DIESEL EXHAUST. THE CO MONITOR READING DROPPED TO 1PPM.

CALIBRATED THE CARBON MONOXIDE MONITOR WITH ZERO GAS AND 101 PPM SPAN GAS PRIOR TO COMMENCING THIS TEST

APPENDIX A
TEST LOG
BAUER DIVERS AIR COMPRESSOR
MODEL K-20 AND P-5 PURIFICATION SYSTEM EVALUATION

COMPRESSOR															
DIESEL ENGINE															
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBIENT HUMIDITY	AMBIENT TEMPERATURE	OIL PRESSURE	ENGINE HEAD TEMPERATURE	AMPERAGE	OIL LEVEL	OIL PRESSURE	FINAL AIR PRESSURE	SERVICE LINE PRESSURE	SERVICE LINE TEMPERATURE	CARBON MONOXIDE BEFORE FILTER	CARBON MONOXIDE AFTER FILTER
5-30	0700	35	05:00	80%	82.9°F	100	160	+5	FULL	810	2000	1700	87.5°F	> 200	< 1
5-30	0800	36	06:00	68%	89.7°F	90	160	+5	FULL	820	2300	2300	101.4°F	> 200	< 1
5-30	0900	37	07:00	63%	92.5°F	90	160	+5	FULL	810	2200	2200	103.2°F	82	< 1
5-30	1000	38	08:00	63%	92.2°F	90	160	+5	FULL	810	2200	2200	102.2°F	50	< 1
5-30	1100	39	09:00	62%	90.1°F	90	160	+5	FULL	810	2150	2150	102.5°F	50	< 1
a 1102 THE IDLER PULLEY CAME LOOSE AND ALLOWED THE BELTS TO JUMP OFF THE FLYWHEEL, SECURED THE COMPRESSOR FOR REPAIRS, RESTARTED AT 1200															
5-30	1200	39	09:00	58%	92.3°F	95	160	+5	FULL	830	1900	2100	92.7°F	65	< 1
5-30	1300	40	10:00	66%	89.7°F	95	160	+5	FULL	810	2000	2000	94.2°F	74	< 1
a 1310 CONDUCTED CAPACITY AIR CHARGE TEST..... CHARGE WAS FROM 1000 TO 2000 PSI IN 14::43															
5-30	1400	41	11:00	66%	87.9°F	95	160	+5	FULL	830	2100	2000	93.6°F	38	< 1
a 1400 SECURED THE COMPRESSOR FOR THE DAY															

COMMENTS

CHECKED THE SYSTEM FOR MINUTE LEAKAGE BY AN OVERNIGHT PRESSURE DROP TEST THE SYSTEM WAS DETERMINED TO HAVE ZERO LEAKAGE.

CHECKED THE CARBON MONOXIDE MONITOR CALIBRATION WITH ZERO GAS AND 101 PPM SPAN GAS PRIOR TO CONTINUING THIS TEST

APPENDIX A TEST LOG

DATE	TIME	LOCATION	TESTER	COMMENTS
11/11/2019	10:00	10000	10000	CHECKED THE CARBON MONOXIDE MONITOR CALIBRATION WITH ZERO GAS AND 101 PPM SPAN GAS PRIOR TO CONTINUING THIS TEST

APPENDIX A TEST LOG

COMMENTS

APPENDIX A TEST LOG

DATE	TIME	LOCATION	EQUIPMENT	OPERATOR	REMARKS
					THE TOXGARD CO MONITOR WAS RECALIBRATED WITH ZERO AND SPAN GAS PRIOR TO START UP

THE TOXGARD CO MONITOR WAS RECALIBRATED WITH ZERO AND SPAN GAS PRIOR TO START UP

APPENDIX A
TEST LOG
BAUER DIVERS AIR COMPRESSOR
MODEL K-20 AND P-5 PURIFICATION SYSTEM EVALUATION

COMPRESSOR															
DIESEL ENGINE															
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBIENT HUMIDITY	AMBIENT TEMPERATURE	COMPRESSOR									
						OIL PRESSURE	ENGINE HEAD TEMPERATURE	AMPERAGE	OIL LEVEL	OIL PRESSURE	FINAL AIR PRESSURE	SERVICE LINE PRESSURE	SERVICE LINE TEMPERATURE	CARBON MONOXIDE BEFORE FILTER	CARBON MONOXIDE AFTER FILTER
6-05	0630	53.5	23.30	82%	83.2°F	100	160	+5	FULL	830	2000	1600	77.8°F	64	< 1
6-05	0700	54	24:00	76%	84.5°F	95	160	+5	FULL	820	2200	2200	91.9°F	58	< 1
6-05	0800	55	25:00	72%	84.3°F	90	160	+5	FULL	820	2200	2200	95.5°F	72	< 1
6-05	0900	56	26:00	64%	87.5°F	90	160	+5	FULL	810	2100	2000	98.6°F	82	< 1
a 0905 CONDUCTED CAPACITY AIR CHARGE TEST.....CHARGE WAS FROM 1000 TO 2000 in 14::04															
6-05	1000	57	27:00	60%	94°F	90	160	+5	FULL	810	2000	1900	97.6°F	74	< 1
6-05	1100	58	28:00	56%	92.6°F	90	160	+5	FULL	800	2100	2000	98.8°F	68	< 1
6-05	1200	59	29:00	54%	97.2°F	90	160	+5	FULL	820	2100	2100	105.3°F	68	< 1
6-05	1300	60	30:00	62%	74.2°F	90	160	+5	FULL	820	2100	2100	96.1°F	57	< 1
6-05	1400	61	31:00	58%	90.8°F	90	160	+5	FULL	800	2100	2100	96.2°F	58	< 1
CO MONITOR CALIBRATION WAS CHECKED PRIOR TO DAILY START UP															
COMMENTS															

APPENDIX A
TEST LOG
BAUER DIVERS AIR COMPRESSOR
MODEL K-20 AND P-5 PURIFICATION SYSTEM EVALUATION

					DIESEL ENGINE				COMPRESSOR						
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBIENT HUMIDITY	AMBIENT TEMPERATURE	OIL PRESSURE	ENGINE HEAD TEMPERATURE	AMPERAGE	OIL LEVEL	OIL PRESSURE	FINAL AIR PRESSURE	SERVICE LINE PRESSURE	SERVICE LINE TEMPERATURE	CARBON MONOXIDE BEFORE FILTER	CARBON MONOXIDE AFTER FILTER
6-06	0630	61	31:00	82%	75.6°F	100	160	+5	FULL	820	2000	2000	80.7°F	64	< 1
6-06	0730	62	32:00	78%	76.8°F	95	160	+5	FULL	820	2100	2100	88.1°F	62	< 1
6-06	0830	63	33:00	65%	82.1°F	95	160	+5	FULL	820	2000	1800	89.4°F	70	< 1
a 0905 CONDUCTED CAPACITY AIR CHARGE TEST.....CHARGE WAS FROM 1000 TO 2000 PSI IN 21::12															
6-06	0930	64	34:00	59%	85.9°F	90	160	+5	FULL	820	2000	1900	94.1°F	78	< 1
6-06	1000	64.5	34:30	62%	80.7°F	90	160	+5	FULL	790	2000	2100	91.2°F	64	< 1

COMMENTS

CO MONITOR CALIBRATION WAS CHECKED PRIOR TO DAILY START UP
THE CHARGE RATE TIME WAS EXCESSIVE AND PROMPTED THE OPERATOR TO CHECK THE SYSTEM FOR LEAKAGE. A BLOWING OIL MIST REVEALED A SUSPECTED CRACK IN THE THIRD STAGE CYLINDER.
09:26 THE UNIT WAS SECURED FOR REPAIRS. MR. ANDY MCKAIG AT BAUER HEAD QUARTERS WAS CONTACTED, HE IN TURN CONTRACTED PNEUMATIC SYSTEMS TO MAKE REPAIRS TO THE UNIT.
THE THIRD STAGE CYLINDER WAS REPLACED AND NEW RINGS INSTALLED ON THE THIRD STAGE FLOATING PISTON.

APPENDIX A
TEST LOG
BAUER DIVERS AIR COMPRESSOR
MODEL K-20 AND P-5 PURIFICATION SYSTEM EVALUATION

DIESEL ENGINE						COMPRESSOR									
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBIENT HUMIDITY	AMBIENT TEMPERATURE	OIL PRESSURE	ENGINE HEAD TEMPERATURE	AMPERAGE	OIL LEVEL	OIL PRESSURE	FINAL AIR PRESSURE	SERVICE LINE PRESSURE	SERVICE LINE TEMPERATURE	CARBON MONOXIDE BEFORE FILTER	CARBON MONOXIDE AFTER FILTER
6-17	0800	65	34.30	76%	85°F	90	160	+5	FULL	820	2000	900	76.2°F	58	< 1
6-17	0900	66	35.30	75%	87.2°F	90	160	+5	FULL	760	2000	2000	94.0°F	54	< 1
6-17	1000	67	36.30	74%	87.8°F	90	160	+5	FILL	820	2000	2000	93.4°F	47	< 1
a 10:15 Start charge rate 1000 to 2000 psig 15::24															
6-17	1100	68	37.30	76%	86.7°F	90	160	+5	FULL	820	2000	1900	92.0°F	52	< 1
6-17	1200	69	38.30	74%	88.7°F	90	160	+5	FULL	820	2100	2100	93.1°F	48	< 1
6-17	1300	70	39.30	66%	90.2°F	90	160	+5	FULL	820	2100	2000	95.3°F	57	< 1
6-17	1400	71	40.30	65%	91.4°F	90	160	+5	FULL	820	2100	2000	95.8°F	54	< 1

COMMENTS

CO MONITOR CALIBRATION WAS CHECKED PRIOR TO DAILY START UP
ONE PINT OF 2190 TEP WAS ADDED TO THE COMPRESSOR TO BRING THE SUMP BACK UP TO OPERATING LEVEL.

**APPENDIX A
TEST LOG
BAUER DIVERS AIR COMPRESSOR
MODEL K-20 AND P-5 PURIFICATION SYSTEM EVALUATION**

DIESEL ENGINE										COMPRESSOR					
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBIENT HUMIDITY	AMBIENT TEMPERATURE	OIL PRESSURE	ENGINE HEAD TEMPERATURE	AMPERAGE	OIL LEVEL	OIL PRESSURE	FINAL AIR PRESSURE	SERVICE LINE PRESSURE	SERVICE LINE TEMPERATURE	CARBON MONOXIDE BEFORE FILTER	CARBON MONOXIDE AFTER FILTER
6-18	0630	71	40:30	86%	80.8°F	90	160	+5	FULL	800	2000	2000	87.6°F	58	< 1
6-18	0730	72	41:30	86%	82.4°F	90	160	+5	FULL	810	2000	1800	84.1°F	62	< 1
6-18	0830	73	42:30	70%	87.3°F	90	160	+5	FULL	790	2000	2000	97.2°F	66	< 1
6-18	0930	74	43:30	75%	84.9°F	90	160	+5	FULL	800	2000	1900	91.3°F	57	< 1
6-18	1030	75	44:30	94%	78.8°F	90	160	+5	FULL	800	2100	2000	87.9°F	58	< 1
6-18	1130	76	45:30	94%	76.2°F	90	160	+5	FULL	800	2100	2000	82.8°F	54	< 1
a 1135 CONDUCTED CAPACITY AIR CHARGE TEST.....CHARGE WAS FROM 1000 TO 2000 PSI IN 15::18															
6-18	1230	77	46:30	92%	78.2°F	90	160	+5	FULL	810	2000	1900	83.7°F	62	< 1
6-18	1330	78	47:30	91%	76.6°F	90	160	+5	FULL	810	2000	1900	83.1°F	57	< 1
6-18	1430	79	48:30	74%	81.6°F	90	160	+5	FULL	800	2000	1500	88.5°F	61	< 1
6-18	1530	80	49:30	70%	87.2°F	90	160	+5	FULL	800	2000	1900	92.4°F	54	< 1
6-18	1600	80.5	50:00	68%	86.2°F	90	160	+5	FULL	800	2000	1800	89.6°F	58	< 1

COMMENTS

CO MONITOR CALIBRATION WAS CHECKED PRIOR TO DAILY START UP.

a 1555 A 50 HOUR AIR SAMPLE WAS TAKEN

THE TEST WAS COMPLETED AND THE UNIT SECURED .

Memorandum

30 May 1991

To: Dave Sullivan, NEDU
From: G. Deason, Code 5130

Subject: Analysis of air sample. Cylinder was labeled as NEDU
test #91-17. Bauer K-20 compressor test and (058825)
(068416) filter test. One hour sample.

1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Sample
Oxygen	21%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	447 PPM
Carbon Monoxide	<0.5 PPM
Total Hydrocarbons*	2.9 PPM
Total Halogens**	<0.5 PPM
Methane	2.9 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
C4+	<0.1 PPM

*Expressed as methane equivalents.

**Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range of the U.S. Navy Diver's Air Purity Standards.



Glen Deason
Chemist

Memorandum

5 June 1991

To: Dave Sullivan, NEDU
From: G. Deason, Code 5130

Subject: Analysis of air sample from the Bauer K-20 compressor test and (058825) (068416) filter test. Twenty five hour sample. NEDU test #91-17.

1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Sample
Oxygen	21%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	471 PPM
Carbon Monoxide	2.0 PPM
Total Hydrocarbons*	2.8 PPM
Total Halogens**	<0.5 PPM
Methane	2.8 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
C4+	<0.1 PPM

*Expressed as methane equivalents.

**Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range of the U.S. Navy Diver's Air Purity Standards.


Glen Deason
Chemist

Memorandum

19 June 1991

To: Dave Sullivan, NEDU
From: G. Deason, Code 5130

Subject: Analysis of air sample from the Bauer K-20 compressor
test and (058825) (068416) filter test. Fifty hour
sample. NEDU test #91-17.

1. In accordance with your request, the air sample delivered to
the gas analysis lab was analyzed and found to contain:

Component	Sample
Oxygen	21%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	371 PPM
Carbon Monoxide	4.9 PPM
Total Hydrocarbons*	4.9 PPM
Total Halogens**	<0.5 PPM
Methane	2.2 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
C4+	<0.7 PPM

*Expressed as methane equivalents.

**Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all
components were within the acceptable range of the U.S. Navy
Diver's Air Purity Standards.


Glen Deason
Chemist