NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 11-91

PLANNED EVALUATION OF BAUER K-280.75 ELECTRIC DRIVE HIGH PRESSURE AIR COMPRESSOR

GEORGE D. SULLIVAN

SEPTEMBER 1991

NAVY EXPERIMENTAL DIVING UNIT

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

IN REPLY REFER TO:
NAVSEA TASK 91-003

NAVY EXPERIMENTAL DIVING UNIT

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UNMANNED EVALUATION OF BAUER K-280.75 ELECTRIC DRIVE HIGH PRESSURE AIR COMPRESSOR

GEORGE D. SULLIVAN

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

In response to NAVSEA tasking, Navy Experimental Diving Unit (NEDU) evaluated the BAUER K-280.75 Electric Powered High Pressure, Breathing Air Compressor from 09 September 1991 to 26 September 1991. The purpose of this evaluation was to determine if the compressor met military specifications making it suitable for use by the U.S. Navy diving community, and eventual addition to the Approved for Navy Use (ANU) List.

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CONTENTS

I. INTRODUCTION

In response to NAVSEA tasking[1], the BAUER electric powered K-280.75 high pressure, breathing air compressor was evaluated by NEDU to determine if the compressor would provide suitable breathing air and have a service life satisfying U.S. Navy requirements for divers air supply compressors.

For the purposes of this evaluation[2], NEDU chose a method consisting of attaching an arrangement of tubing and valves from the high pressure discharge to a 42 ft floodable volume flask. The arrangement consisted of a vent valve, sample bottle fill valve, 5000 psi gauge and tubing to the flask. At startup the compressor charged the storage flasks to 2000 psig, then 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.

Random charge rates were taken on a daily basis while compressing from 2000 psig to 3000 psig. The compressor was operated a total of 40.5 hours.

The manufacturer shipped the compressor configured as a 3000 psi unit. After 24 hours of operation they shipped a 4th stage relief valve and temperature probe to change the compressor to a 5000 PSI unit.

II. EQUIPMENT DESCRIPTION

The BAUER K-280.75 high pressure air compressor is driven by six V belts from a Toshiba 59 hp 1765 rpm 220/460 vac electric motor. The unit has a panel with four stage pressure gauges, one oil pressure gauge and three indicator lights for power on, high temperature and low oil pressure. The motor and compressor units are mounted on a frame set on vibration absorbers. The vibration absorbers are mounted on a skid type frame. The K-280.75 is rated to provide 100 cubic feet per minute (cfm) of free air compressed to 5000 pounds per square inch (psi). The unit is rated to operate in temperatures ranging from 41°F to 95°F. In lower temperatures a heating device is used to pre-heat the crankcase.

A. COMPRESSOR

The compressor is a three-cylinder, four-stage, reciprocating, air-cooled unit. The cylinders are arranged in the form of an inverted T. The first and second stage cylinders are lubricated by means of a force-fed lubrication system while the other cylinder is splash lubricated. The cylinders of the compressor block, the intermediate coolers, and the after cooler are air-cooled. The compressor is equipped with two cooling fans which moves the cooling air over inter- and after- coolers and compressor cylinders.

III. TEST PROCEDURE AND RESULTS

The compressor unit and ancillary equipment were set up in accordance with the NEDU test plan[2] and the K-280.75 compressor maintenance manual[3]. 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 ambient and compressor discharge temperatures.

The K-280.75 compressor maintenance manual[3] was used to conduct an initial receipt inspection of the equipment to ensure all parts and material were received.

A. ENDURANCE TEST

The compressor was operated with no load the first hour of the test. No load conditions consisted of the vent open and the back pressure valve set at 2175 psig. An air sample was taken after one hour. The compressor was operated daily with the vent adjusted to maintain the predetermined discharge pressure. During capacity evaluation the compressor was attached by flexible hose to a 42 cubic ft floodable volume flask. The capacity was verified by charging the flask from 2000 psi to 3000 psig. A total of 45.5 hours of operation were logged. The following parameters were recorded:

(1) Date
(2) Time
(3) Total meter hours
(4) Total test hours
(5) Ambient Temperature
(6) Stage 1 pressure
(7) Stage 2 pressure
(8) Stage 3 pressure
(9) Stage 4 pressure
(10) Stage 1 Temperature
(11) Stage 2 Temperature
(12) Stage 3 Temperature
(13) Stage 4 Temperature
(14) Compressor oil level
(15) Compressor oil pressure
(16) Compressor discharge line temperature

B. OIL CONSUMPTION

Prior to beginning the test, the oil sump in the compressor was measured as full on the dip stick. The compressor oil was changed 13 hours into the test (28.8 hours on the total hour meter) per the maintenance manual[3]. Bauer Co. supplied eight gallons of BP Energol RC-150 oil for the change. Compressor oil level was checked each morning. Oil consumption was considered negligible.

C. AIR SAMPLING

Air samples were taken from the compressor discharge at test hours one and 25 and sent to the NCSC Laboratory, Code 5130, for purity analysis. Results are attached as Appendix B. Both samples were within established limits[4].

D. MAINTENANCE

Scheduled maintenance was performed at the times indicated in the maintenance manual[3]. Those scheduled maintenance actions performed consisted of the following:

- Checked valve function at 30 minutes after startup (daily).

- Checked oil level (daily)

- Changed oil at 25 hours on the total hour meter

- Checked automatic condensate drain (daily)

E. PROBLEMS ENCOUNTERED

During the original startup of the unit at NEDU, the automatic condensate drain did not activate for a period of 44 minutes. The illustrations of the timers in the manual are not the same item installed in the unit. The timers had to be set to their indicated three minute position to get them to actually actuate at the proper 15 minute intervals.

No.1 cylinder head developed an oil leak around the head gasket. After 40.5 hours approximately two teaspoons of oil had collected on the cooling fins. Oil could be seen bubbling at the gasket joint.

The high pressure air discharge line from the forth stage developed an oil leak.

Three of the six drive belts twisted and started to deteriorate, indicating a motor and compressor misalignment. There is no procedure in the maintenance manual[3] or aligning or checking alignment of the belts.

The pressure maintaining/non-return valve failed and begin discharging directly to atmosphere. The manual[3] gives only a functional description of the valve but no information to assist in attempting repairs.

The accompanying manual[3] provides detailed information of the K-280.75 compressor block. It does not provide detailed information concerning the accessory components on the unit.

When the ambient temperature dropped to 55°F over night, the compressor oil was chilled so the unit had to be restarted three times to pickup enough oil pressure to continue running.

IV. CONCLUSIONS

It is expected that equipment tested by NEDU is received in the same mechanical condition as a unit delivered to the Fleet. It should not require any repairs or alterations. The problems listed above, considered as mechanical malfunctions and breakdowns, resulted in termination of testing. This unit is not recommended for inclusion in the ANU list[5].

V. REFERENCES

1. NAVSEA Task 91-003; Testing of commercially available air compressors for divers use for ANU list.

2. NEDU Test Plan No. 91-37 Bauer K-280.75 Electric Drive High Pressure Air Compressor Evaluation

3. Bauer Maintenance Manual High Pressure Compressor Block K-280

4. U.S. Navy Diving Manual, Vol. 1, NAVSEA 0994-LP-001-9010, Air Purity Standards

5. NAVSEAINST 10560.2 (Series); Diving Equipment Authorized for Navy Use.

TEST LOG
BAUER K-28 (MOD-1)
ELECTRIC HP AIR COMPRESSOR EVALUATION

					STAGE PRESSURES				STAGE TEMPERATURES				COMPRESSOR				
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBI TEMP	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	OIL LEVEL	OIL PRESSURE	DISCHG LINE PRESSURE	DISCHG LINE TEMP	
09-18	1300	13.0	00.00	84°F	62	290	960	2100					FULL	52	2100		
09-18	1400	14.0	1.0	83.4°F	62	280	960	2200	350°F	338°F	191°F	203°F	FULL	52	2200	103.4°F	
09-19	0630	14.0	1.0	72°F	60	260	940	2100	194°F	167°F	140°F	203°F	FULL	50	2000	68°F	
09-19	0730	15.0	2.0	76.1°F	61	265	940	2350	358°F	348°F	194°F	214°F	FULL	55	2200	102.7°F	
09-19	0830	16.0	3.0	77.8°F	60	260	950	2750	320°F	268°F	194°F	257°F	FULL	55	2700	94.3°F	
09-19	0930	17.0	4.0	80.4°F	62	270	930	2700	285°F	248°F	216°F	257°F	FULL	55	2600	113.9°F	
09-19	1030	18.0	5.0	83.6°F	60	270	930	2850	296°F	257°F	212°F	248°F	FULL	55	2800	113.9°F	
09-19	1130	19.0	6.0	87.0°F	60	270	920	2800	304°F	238°F	216°F	257°F	FULL	55	2700	120.4°F	
09-19	1230	20.0	7.0	93.3°F	60	270	920	2750	320°F	238°F	248°F	257°F	FULL	55	2700	126.7°F	
09-19	1330	21.0	8.0	91.3°F	60	270	920	2750	328°F	248°F	248°F	257°F	FULL	55	2700	127.7°F	
09-19	1400	21.5	8.5	89.4°F	60	270	920	2750	328°F	248°F	248°F	257°F	FULL	55	2700	120.4°F	

COMMENTS

09-18 1400 TOOK ONE HOUR AIR SAMPLE ADJUSTED AUTO CONDENSATE DRAIN TIMERS CHECK COMPRESSOR OIL LEVEL

09-19 0810 TOOK CHARGE RATE IT TOOK 20::58 TO CHARGE FROM 2000 TO 3000 PSI

TEST LOG
BAUER K-28 (MOD-1)
ELECTRIC HP AIR COMPRESSOR EVALUATION

					STAGE PRESSURES				STAGE TEMPERATURES				COMPRESSOR				
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBI TEMP	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	OIL LEVEL	OIL PRESSURE	DISCHG LINE PRESSURE	DISCHG LINE TEMP	
09-20	0630	21.5	8.5	68.5°F	60	255	930	2300	176°F	141°F	113°F	113°F	FULL	48	2200	70.4°F	
09-20	0730	22.5	9.5	69.0°F	62	270	920	2300	285°F	230°F	194°F	167°F	FULL	55	2200	92.7°F	
09-20	0830	23.5	10.5	70.8°F	60	270	920	2250	285°F	240°F	194°F	176°F	FULL	55	2100	93.7°F	
09-20	0930	24.5	11.5	76.5°F	60	270	920	2250	295°F	248°F	194°F	185°f	FULL	55	2100	94.6°f	
09-20	1030	25.5	12.5	79.4°F	60	270	920	2250	295°F	248°F	203°F	176°F	FULL	55	2100	100.7°F	
09-20	1130	26.5	13.5	80.9°F	60	270	920	2200	295°F	257°F	212°F	203°F	FULL	55	2100	105.0°F	
09-20	1230	27.5	14.5	86.1°F	60	270	920	2150	295°F	257°F	212°F	212°F	FULL	55	2500	106.2°F	
09-20	1330	28.5	15.5	86.2°F	60	270	930	2600	312°F	268°F	248°F	212°F	FULL	55	2500	109.9°F	
09-20	1348	28.8	15.8	87.3°F	60	270	940	3100	312°F	268°F	257°F	212°F	FULL	55	3000	114.4°F	AUTO SHUTDOWN TEST

COMMENTS

1135 TOOK CHARGE RATE IT TOOK :22::05 TO CHARGE FROM 2000 TO 3000 PSI

AT 1345 THE VENT VALVES WERE CLOSED AND THE UNIT ALLOWED TO BUILD PRESSURE ABOVE 3000PSI. THE CUTOUT SWITCH FUNCTIONED PROPERLY AND THE UNIT SHUTOFF AT 1348 IT WAS ALLOWED TO COOL AND THE 25 HOUR BREAK-IN OIL CHANGE WAS DONE

TEST LOG
BAUER K-28 (MOD-1)
ELECTRIC HP AIR COMPRESSOR EVALUATION

					STAGE PRESSURES				STAGE TEMPERATURES				COMPRESSOR				
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBI TEMP	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	OIL LEVEL	OIL PRESSURE	DISCHG LINE PRESSURE	DISCHG LINE TEMP	
09-23	0630	28.8	15.8	72.6°F	62	270	925	2200	257°F	212°F	140°F	203°F	FULL	52	2200	80.9°F	
09-23	0730	29.8	16.8	74.8°F	62	270	925	2200	285°F	230°F	212°F	203°F	FULL	54	2100	99.8°F	
09-23	0830	30.8	17.8	80.0°F	62	270	925	2400	230°F	230°F	212°F	285°F	FULL	54	2350	105.6°F	
09-23	0930	31.8	18.8	87.0°F	62	270	930	2550	295°F	230°F	212°F	248°F	FULL	54	2500	112.5°F	
09-23	0942	32.0	19.0	89.4°F	62	270	930	2550	295°F	230°F	212°F	248°F	FULL	54	2500	114.7°F	
09-23	1030	32.0	19.0	95.2°F	60	255	925	2600	212°D	203°F	140°F	149°F	FULL	50	2500	86.9°F	
09-23	1130	33.0	20.0	93.8°F	60	270	925	2300	312°F	257°F	212°F	212°F	FULL	54	2200	109.9°F	
09-23	1230	34.0	21.0	91.4°F	60	270	925	2400	320°F	257°F	222°F	212°F	FULL	54	2300	112.9°F	
09-23	1330	35.0	22.0	92.8°F	60	270	925	2400	320°F	328°F	222°F	212°F	FULL	54	2300	114.5°F	
09-23	1430	36.0	23.0	93.6°F	60	270	910	2000	306°F	257°F	212°F	212°F	FULL	54	1950	101.3	

COMMENTS

0942 IMPROPER ADJUSTMENT OF THE VENT VALVES CAUSED THE UNIT TO CYCLE ON THE HP CUTOFF SWITCH. RESTART AT 1030 TO KEEP METER AND TEST HRS ON EVEN TIME

1340 TOOK CHARGE RATE IT TOOK 22::17 TO CHARGE FROM 2000 TO 3000 PSIG

TEST LOG
BAUER K-28 (MOD-1)
ELECTRIC HP AIR COMPRESSOR EVALUATION

					STAGE PRESSURES				STAGE TEMPERATURES				COMPRESSOR				
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBI TEMP	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	OIL LEVEL	OIL PRESSURE	DISCHG LINE PRESSURE	DISCHG LINE TEMP	
09-24	0630	36.0	23.0	76.8°F	60	250	920	2100	167°F	140°F	104°F	104°F	FULL	48	1700	73.2°F	
09-24	0730	37.0	24.0	79.0°F	60	270	925	2500	304°F	257°F	222°F	248°F	FULL	55	2400	110.2°F	
09-24	0800	37.0	24.0	84.0	62	275	960	4350	295°F	238°F	212°F	312°F	FULL	55	4200	119.2°F	
09-24	0900	38.0	25.0	85.4	62	275	960	4300	304°F	238°F	203°F	295°F	FULL	55	4200	122.3°F	

COMMENTS
0730 SECURE COMPRESSOR INSTALL 5000PSI RELIEF VALVE, RESET HP CUTOUT SWITCH TO 5100 PSI

TEST LOG
BAUER K-28 (MOD-1)
ELECTRIC HP AIR COMPRESSOR EVALUATION

					STAGE PRESSURES				STAGE TEMPERATURES				COMPRESSOR				
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBI TEMP	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	OIL LEVEL	OIL PRESSURE	DISCHG LINE PRESSURE	DISCHG LINE TEMP	
09-25	0630	38.0	25.0	71.2°F	60	270	950	3800	167°F	150°F	104°F	104°F	FULL	48	3700	74.2°F	
09-25	0730	39.0	26.0	74.3°F	62	280	970	4700	268°F	248°F	212°F	330°F	FULL	54	4600	122.6°F	
09-25	0830	40.0	27.0	73.9°F	62	280	970	4700	320°F	248°F	203°F	320°F	FULL	54	4600	120.6°F	
09-25	0930	41.0	28.0	76.5°F	62	290	970	4850	295°F	257°F	212°F	302°F	FULL	54	4800	120.0°F	
09-25	1030	42.0	29.0	81.6°F	62	280	960	4700	285°F	266°F	212°F	312°F	FULL	54	4600	122.1°F	
09-25	1130	43.0	30.0	81.6°F	62	280	960	4750	285°F	268°F	212°F	338°F	FULL	54	4600	124.9°F	
09-25	1230	44.0	31.0	86.2°F	62	280	960	4700	295°F	257°F	222°F	348°F	FULL	54	4600	132.5°F	
09-25	1330	45.0	32.0	82.1°F	62	280	965	4900	295°F	257°F	230°F	338°F	FULL	54	4800	132.3°F	
09-25	1400	45.5	32.5	85.6°F	62	280	960	4600	295°F	257°F	230°F	338°F	FULL	54	4500	125.2°F	

COMMENTS

0640 TOOK 25 HOUR AIR SAMPLE

1235 TOOK CHARGE RATE IT TOOK :21::25 TO CHARGE FROM 2000 TO 3000PSI

TEST LOG
BAUER K-28 (MOD-1)
ELECTRIC HP AIR COMPRESSOR EVALUATION

					STAGE PRESSURES				STAGE TEMPERATURES				COMPRESSOR				
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBI TEMP	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	1 ST STAGE	2 ND STAGE	3 RD STAGE	4 TH STAGE	OIL LEVEL	OIL PRESSURE	DISCHG LINE PRESSURE	DISCHG LINE TEMP	
09-26	0630	45.5	32.5	63.7°F	60	250	920	2200	167°F	130°F	122°F	122°F	FULL	45	1800	60°F	
09-26	0730	46.5	33.5	62.5°F	62	280	970	4800	257°F	230°F	194°F	302°F	FULL	54	4700	111.4°F	
09-26	0830	47.5	34.5	68.3°F	62	280	960	4800	312°F	230°F	194°F	266°F	FULL	54	4700	113.5°F	
09-26	0930	48.5	35.5	72.6°F	62	280	970	4700	282°F	257°F	194°F	302°F	FULL	54	4600	113.6°F	
09-26	1030	49.5	36.5	74.8°F	62	280	970	4700	275°F	257°F	203°F	320°F	FULL	54	4600	119.8°F	
09-26	1130	50.5	37.5	78.9°F	62	280	970	4700	295°F	257°F	212°F	312°F	FULL	54	4600	122.3°F	
09-26	1230	51.5	38.5	83.5°F	62	280	970	4700	295°F	257°F	212°F	312°F	FULL	54	4600	122.1°F	
09-26	1330	52.5	39.5	81.4°F	62	280	970	4850	295°F	257°F	212°F	320°F	FULL	54	4750	122.3°F	
09-26	1430	53.5	40.5	86.3°F	62	280	970	4850	302°F	257°F	212°F	312°F	FULL	54	4750	117.8°F	

COMMENTS

1235 TOOK CHARGE RATE IT TOOK :20::34 TO CHARGE FROM 2000 PSI TO 3000 PSI

Memorandum 18 September 1991

To: Dave Sullivan, NEDU

From: G. Deason, Code 5130

Subject: Analysis of air sample from Bauer K280 compressor evaluation. 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	350 PPM
Carbon Monoxide	1.2 PPM
Total Hydrocarbons*	2.5 PPM
Total Halogens**	<0.5 PPM
Methane	2.5 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
Formaldehyde	<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 26 September 1991

To: Dave Sullivan, NEDU

From: G. Deason, Code 5130

Subject: Analysis of Bauer K-280 compressor evaluation air sample. Twenty-five 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	336 PPM
Carbon Monoxide	4.3 PPM
Total Hydrocarbons*	2.6 PPM
Total Halogens**	<0.5 PPM
Methane	1.4 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
Formaldehyde	<0.1 PPM
C4+	<0.3 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