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|-----------------------------------------------------------------------------------------|-----------------------------------|--------|
| AEROSPACE<br>STANDARD                                                                   | AS19692™                          | REV. B |
|                                                                                         | Issued 1959-02<br>Revised 2016-06 |        |
|                                                                                         | Superseding AS19692A              |        |
| (R) Aerospace – Military Type Variable Delivery,<br>Pressure Compensated Hydraulic Pump |                                   |        |

## RATIONALE

AS19692 has been updated to Revision B for the following reasons:

- Additional technical requirements and information have been introduced.
- Technical and editorial corrections have been made
- The references cited within the document have been updated.

## FOREWORD

Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DoD contracts. However, requirements relating to qualified products lists (QPLs) have not been adopted by SAE and are not part of this SAE technical document.

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## 1. SCOPE

This SAE Aerospace Standard (AS) establishes the general requirements for the design, construction, acceptance, and qualification testing of flat cut-off pressure compensated, variable delivery hydraulic pumps used in military aircraft hydraulic systems. It also provides parameters for a Procurement Specification to be used in conjunction with this AS.

The hydraulic pumps defined by this AS are generally for use in aircraft hydraulic systems conforming to and as defined in AS5440 and MIL-H-8891, as applicable.

### NOTES:

1. Hydraulic pumps may incorporate features such as a clutch in the input drive, which will not be covered by this standard.
2. AS595 should be used for commercial aircraft hydraulic pumps.
3. This document should not be used for hydraulic pumps in Electro-Hydrostatic Actuator applications (EHAs).

### 1.1 Field of Application

The hydraulic pumps are intended for engine driven applications and use on aircraft for hydraulic operation of such mechanisms as:

- Powered flight control systems
- Landing gear
- Brakes
- Flaps
- Servoactuators
- Doors

The pumps are primarily intended to be driven by the airplane turbine engine and to supply fluid to systems in accordance with AS5440 or MIL-H-8891, as applicable. When driven by other means or used in uninhabited aircraft, additional tests and separate approval may be required by the contracting activity.

## 2. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of the other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

#### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

AMS-QQ-N-290 Nickel Plating (Electrodeposited) (DoD Adopted)

AMS-QQ-P-416 Plating, Cadmium (Electrodeposited) (DoD Adopted)

|         |                                                                                                                                                                                                                     |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AS567   | Safety Cable, Safety Wire, Key Washers, and Cotter Pins for Propulsion Systems, General Practices for Use of                                                                                                        |
| AS595   | Aerospace – Civil Type Variable Delivery, Pressure Compensated, Hydraulic Pump                                                                                                                                      |
| AS1300  | Port – Ring Locked Fluid Connection Type Standard Dimensions for                                                                                                                                                    |
| AIR1362 | Aerospace Hydraulic Fluids Physical Properties                                                                                                                                                                      |
| ARP1383 | Aerospace – Impulse Testing of Hydraulic Components                                                                                                                                                                 |
| AIR1922 | Aerospace – System Integration Factors That Affect Hydraulic Pump Life                                                                                                                                              |
| AMS2404 | Plating, Electroless Nickel                                                                                                                                                                                         |
| AMS2460 | Plating, Chromium                                                                                                                                                                                                   |
| AS4201  | Port – Ring Locked Fluid Connection Type, 8000 PSI Design Standard                                                                                                                                                  |
| ARP4386 | Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies                                                                                                                           |
| AS5440  | Hydraulic Systems, Military Aircraft, Design and Installation, Requirements For                                                                                                                                     |
| AIR5872 | Aerospace Hydraulic Pump Controls                                                                                                                                                                                   |
| AMS7259 | Rubber: Fluorocarbon (FKM) High Temperature/Fluid Resistant Low Compression Set/ 85 to 95 Hardness For Seals In Fuel Systems and Specific Engine Oil Systems                                                        |
| AMS7276 | Rubber: Fluorocarbon (FKM) High-Temperature-Fluid Resistant Low Compression Set for Seals in Fuel Systems and Specific Engine Oil Systems                                                                           |
| AMS7287 | Fluorocarbon Elastomer (FKM) High Temperature / HTS Oil Resistant / Fuel Resistant Low Compression Set / 70 to 80 Hardness, Low Temperature Tg -22 °F (-30 °C) For Seals in Oil / Fuel / Specific Hydraulic Systems |
| AMS7379 | Rubber: Fluorocarbon Elastomer (FKM) 70 to 80 Hardness, Low Temperature Sealing Tg -40 °F (-40 °C) For Elastomeric Seals in Aircraft Engine Oil, Fuel and Hydraulics Systems                                        |
| AS8775  | Hydraulic System Components, Aircraft and Missiles, General Specification For                                                                                                                                       |

#### 2.1.2 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, [www.aia-aerospace.org](http://www.aia-aerospace.org).

|           |                                                                               |
|-----------|-------------------------------------------------------------------------------|
| NAS847    | Caps and Plugs, Protective, Dust and Moisture Seal, General Specification for |
| NASM33540 | Safety Wiring, Safety Cabling, Cotter Pinning, General Practices for          |

### 2.1.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, [www.astm.org](http://www.astm.org).

ASTM B545 Tin Plating; Electrodeposited or Hot Dipped, for Ferrous and Nonferrous Metals (DoD Adopted)

ASTM B633 Zinc on Iron & Steel, Electrodeposited Coatings of (DoD Adopted)

ASTM B700 Silver Plating, Electrodeposited; General Requirements for

### 2.1.4 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

MIL-STD-130 Identification Marking of U.S. Military Property

MIL-STD-276 Impregnation of Porous Nonferrous Metal Castings and Powdered Metal Components

MIL-STD-464 Electromagnetic Environmental Effects Requirements for Systems

MIL-HDBK-781 Military Handbook: Reliability Test Methods, Plans, and Environments for Engineering, Development Qualification, and Production

MIL-STD-810 Environmental Test Methods and Engineering Guidelines

MIL-STD-2073-1 Preservation, Methods of

MIL-A-8625 Anodic Coatings for Aluminum and Aluminum Alloys

MIL-DTL-5541 Chemical Conversion Coatings on Aluminum and Aluminum Alloys

MIL-F-8815 Filter and Filter Elements, Fluid Pressure, Hydraulic Line, 15 Micron Absolute & 5 Micron Absolute, Type II Systems General Specification for

MIL-H-8890 Hydraulic Components, Type III (-65°F to Plus 450°F), General Specification for (ASG)

MIL-H-8891 Hydraulic Systems, Manned Flight Vehicles, Type III Design, Installation and Data Requirements for, General Specification for (Inactive for New Design)

MIL-C-11796 Corrosion Preventive Compound, Petrolatum, Hot Application

MIL-DTL-15024 Plates, Tags, and Bands for Identification of Equipment

MIL-PRF-16173 Corrosion Preventive Compound, Solvent Cutback, Cold-Application

MS3330 Flange/Accessory, 2.653 BC Square, Design Standard for (Inactive for New Design)

MS3331 Flange Accessory, 5.000 BC Square, Design Standard for (Inactive for New Design)

MS3332 Flange Accessory, 5.000 BC Round, Design Standard for (Inactive for New Design)

MS3333 Flange Accessory, 8.000 BC Round, Design Standard for (Inactive for New Design)

MS3334 Flange Accessory, 10.000 BC Round Design Standard for (Inactive for New Design)

MS21344 Fitting-Installation of Flared Tube, Straight Threaded Connectors, Design Standard for

## 2.2 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, and MS standards), the text of this document shall take precedence. Nothing in this document, however supersedes applicable laws and regulations unless a specific exemption has been obtained.

## 2.3 Definitions

Refer to ARP4386 for general hydraulic system terms that are used in this Aerospace Standard.

**DISCHARGE PRESSURE PULSATIONS:** Discharge pressure pulsations are the oscillations of the discharge pressure, occurring during nominally steady operating conditions, at a frequency equal to the number of pistons times the drive shaft speed, or a multiple thereof. The amplitude of the oscillations is the difference between the average minimum and the average maximum oscillations recorded during a time trace of at least one-second in duration.

**NOTE:** This is a characteristic of the pump and the system operating together.

**DISPLACEMENT:** The displacement of the pump is the theoretical volume of the hydraulic fluid delivered in one revolution of its drive shaft. It is expressed as cubic inches per revolution (cubic inch/rev) or milliliters per revolution (mL/rev). The displacement of any pump model shall be determined by calculation from the geometry and dimensions of the pump. The effects of allowable manufacturing tolerances, deflections of the pump structure, compressibility of the hydraulic fluid, internal leakage and temperature are to be excluded from the calculation because the displacement is intended to be an index of the size of the pump rather than of its performance.

**FLAT CUT-OFF PRESSURE COMPENSATED, VARIABLE DELIVERY HYDRAULIC PUMP:** This is a pump that provides a nearly constant pressure at the pump output at all flows lower than the maximum flow capacity of the pump.

**HEAT REJECTION:** The difference between the input shaft power and output fluid power of the pump at specified conditions.

**MAXIMUM CASE DRAIN PRESSURE:** The maximum case drain pressure is the maximum continuous pressure at the pump case drain port as dictated by the installed system.

**MAXIMUM INLET PRESSURE:** The maximum inlet pressure is the maximum steady state inlet pressure at which the pump may be required to operate.

**MAXIMUM TRANSIENT CASE DRAIN PRESSURE:** The maximum transient case drain pressure is the maximum pressure at the pump case drain port during pump transients as dictated by the installed system.

**MAXIMUM TRANSIENT DISCHARGE PRESSURE:** The maximum transient discharge pressure is defined as the peak value of the discharge pressure recorded during a discrete transient event (normally found when cycling from full-flow pressure to rated pressure (zero flow)).

**MINIMUM INLET PRESSURE:** The minimum inlet pressure is the lowest inlet pressure at which the pump may be required to operate during a system failure or during a system high flow transient condition.

**PUMP CASE DRAIN PORT (also called the PUMP COOLING PORT):** The pump case drain port is the location where the pump case leakage flow is directed out of the pump and returned to the hydraulic system.

**PUMP INLET PORT (also called the PUMP SUCTION PORT):** The pump inlet port is the location where the fluid is supplied to the pump by the hydraulic system reservoir.

**PUMP OUTLET PORT (also called the PRESSURE PORT or the DELIVERY PORT or the DISCHARGE PORT):** The pump outlet port is the location where the pump discharges pressurized flow to the hydraulic system.

**PUMP OVERALL EFFICIENCY:** The pump overall efficiency (including volumetric efficiency) is defined as a ratio of the pump output power (hydraulic) to the pump input power (mechanical) and includes the fluid compressibility. This is obtained from the following equations:

$$\text{Pump Overall Efficiency(\%)} = \frac{\text{Output Fluid Power}}{\text{Input Shaft Power}} \times 100 \quad (\text{Eq. 1})$$

where:

$$\text{Input Shaft Power} = \text{Shaft Torque} \times \text{RPM} \quad (\text{Eq. 2})$$

To include the effects of expanded flow or compressed flow for output fluid power, the following equations should be used:

$$\text{Output Fluid Power} = \text{Pressure Differential} \times \text{Expanded Flow Rate} \times \left(1 - \frac{\Delta P}{2 \cdot B}\right) \quad (\text{Eq. 3})$$

or

$$\text{Output Fluid Power} = \text{Pressure Differential} \times \text{Compressed Output Flow Rate} \times \frac{(2 \cdot B - \Delta P)}{[2 \times (B - \Delta P)]} \quad (\text{Eq. 4})$$

where:

$\Delta P$  = Pressure Differential = Discharge Pressure – Inlet Pressure

$B$  = Adiabatic Secant Bulk Modulus, determined with the pressure equal to the average of the pump inlet and outlet pressures. Values of Adiabatic Secant Bulk Modulus as a function of pressure and temperature can be obtained from AIR1362.

**PUMP SHAFT DRAIN PORT** (also called the DRAIN PORT or the SHAFT SEAL PORT): The pump shaft drain port is the location where any shaft seal leakage flow is collected for external drainage.

**PURCHASER:** The Purchaser is the organization that has the engineering responsibility for the hydraulic system that includes the pump. Typically, the Purchaser is an aircraft manufacturer, a system supplier or a modification center. The Purchaser is responsible for the compilation of the Procurement Specification.

**PROCUREMENT SPECIFICATION:** The Procurement Specification is the document that includes the following:

- a. Technical requirements
- b. Acceptance and qualification test requirements
- c. Reliability requirements
- d. Quality requirements
- e. Packaging requirements

**RATED CASE DRAIN PRESSURE:** The rated case drain pressure is the maximum pressure at the pump case port at which the pump is required to operate continuously in the system.

**RATED DISCHARGE PRESSURE:** The rated discharge pressure is the minimum pressure that the pump is required to maintain at rated fluid temperature, rated speed, rated inlet pressure, rated case drain pressure and at zero flow as illustrated in Figure 1.

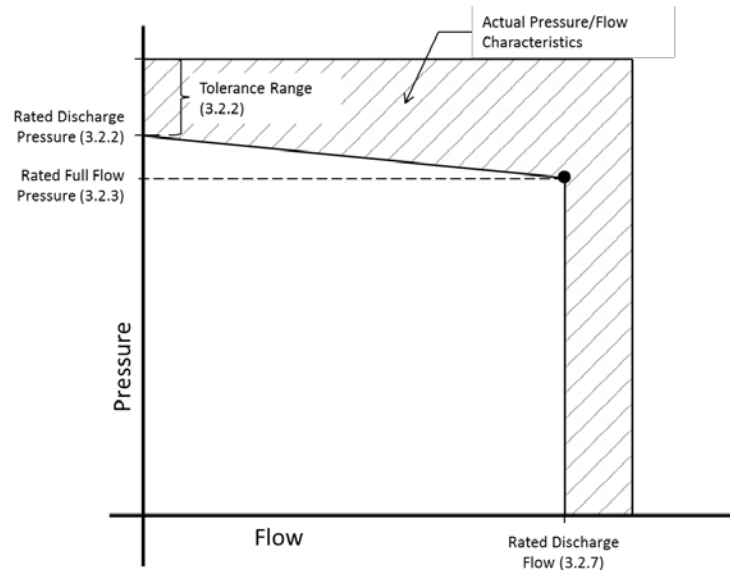


**Figure 1 - Pressure/flow characteristics of a flat cut-off pressure compensated, variable flow hydraulic pump**

NOTES:

1. This diagram is given as an illustration, is not to scale, and may be presented in a different way, for example, the axes may be reversed.
2. The Procurement Specification may specify the minimum, maximum, or nominal zero-pressure flow.

**RATED DISCHARGE FLOW:** The rated flow of a pump is the measured volumetric fluid output of the pump as illustrated in Figure 1 under conditions of:

- Rated fluid temperature
- Rated speed
- Rated inlet pressure
- Rated case drain pressure
- Rated full flow pressure
- Using the hydraulic fluid specified in the Procurement Specification

**NOTE:** The flow is measured in the compressed state. If the flow is measured in the expanded state, for instance on the low pressure side of a load valve, the following equation can be used to adjust the flow rate for compressibility.

$$\text{Compressed Flow Rate} = \text{Expanded Flow Rate} \times \left(1 - \frac{\Delta P}{B}\right)$$

(Eq. 5)

where:

$\Delta P$  = Pressure Differential = Discharge Pressure – Inlet Pressure

B = Adiabatic Bulk Modulus, determined with the pressure equal to the average of the pump inlet and outlet pressures. Values of Adiabatic Bulk Modulus as a function of pressure and temperature can be obtained from AS19692.

**RATED FULL FLOW PRESSURE:** The minimum outlet pressure at which the pump is required to produce full flow as illustrated in Figure 1.

**RATED INLET PRESSURE:** The rated inlet pressure is the minimum pressure when operating at rated speed, rated full flow pressure and rated temperature as measured at the pump inlet port of the pump in a manner which indicates the static head and is expressed in psia or kPa absolute.

**RATED SPEED:** The rated speed is the maximum speed at which the pump is designed to operate continuously at rated temperature.

**RATED FLUID TEMPERATURE:** The rated fluid temperature is the maximum continuous temperature of the fluid to be supplied at the inlet port of the pump.

**RESPONSE TIME:** The response time is the rate of change of displacement of the pump when subjected to a specific discharge circuit transient. On most pump models it is not possible to measure the pump displacement. Instead, a test can be carefully designed wherein it is possible to deduce the change in displacement of the pump by the inspection of the pump discharge pressure. This measurement is called "Response Time" as it is a dynamic characteristic of a pump operating in a specified discharge circuit. It is not strictly an attribute of the pump. For this reason, the term "Response Time" is used throughout this document instead of "Pump Response Time". In such a test, the response time is the time interval between the instant when an increase (or decrease) in discharge pressure change initiates; and the subsequent instant when the discharge pressure reaches its first maximum (or minimum) value.

In Figures 2 and 3, the time intervals  $T_1$  and  $T_2$  are the response times as a function of the system impedance. The real-time plot of discharge pressure versus time shall be employed as the criterion of movement of the flow control mechanism.

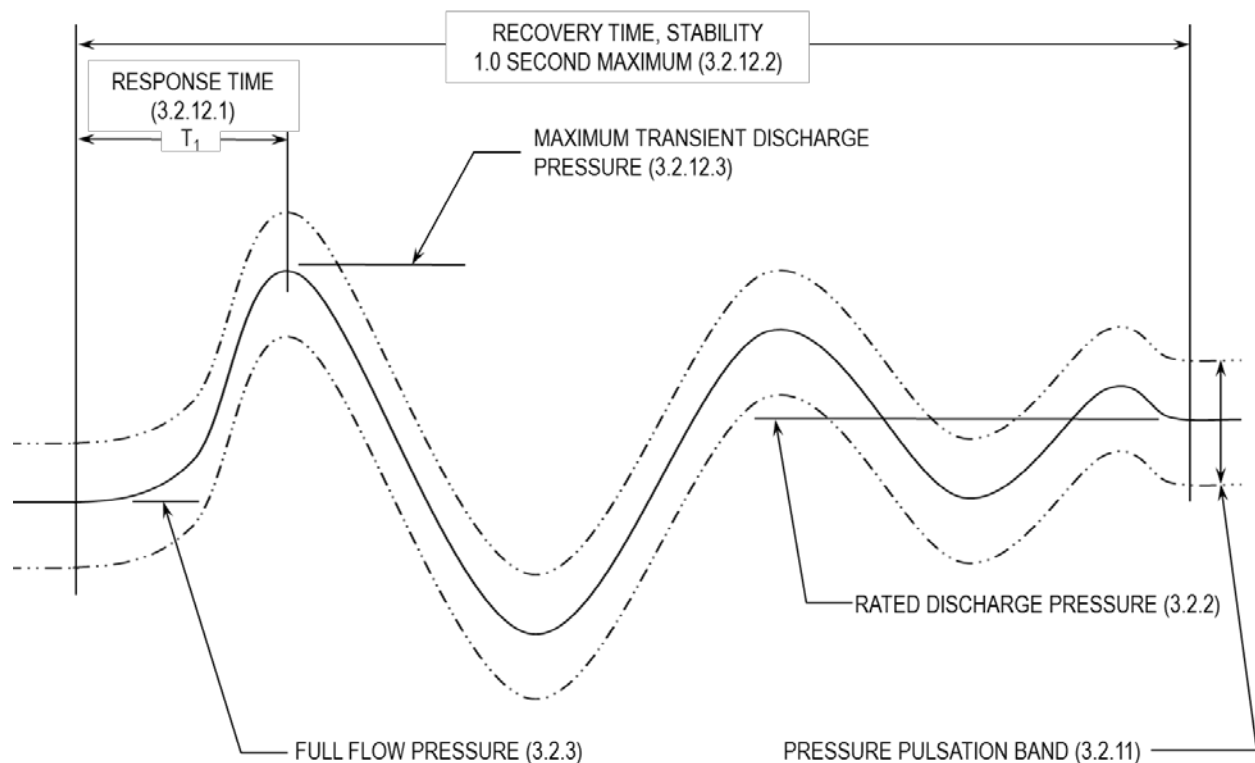


**Figure 2 - Typical pressure transient full flow to zero flow**

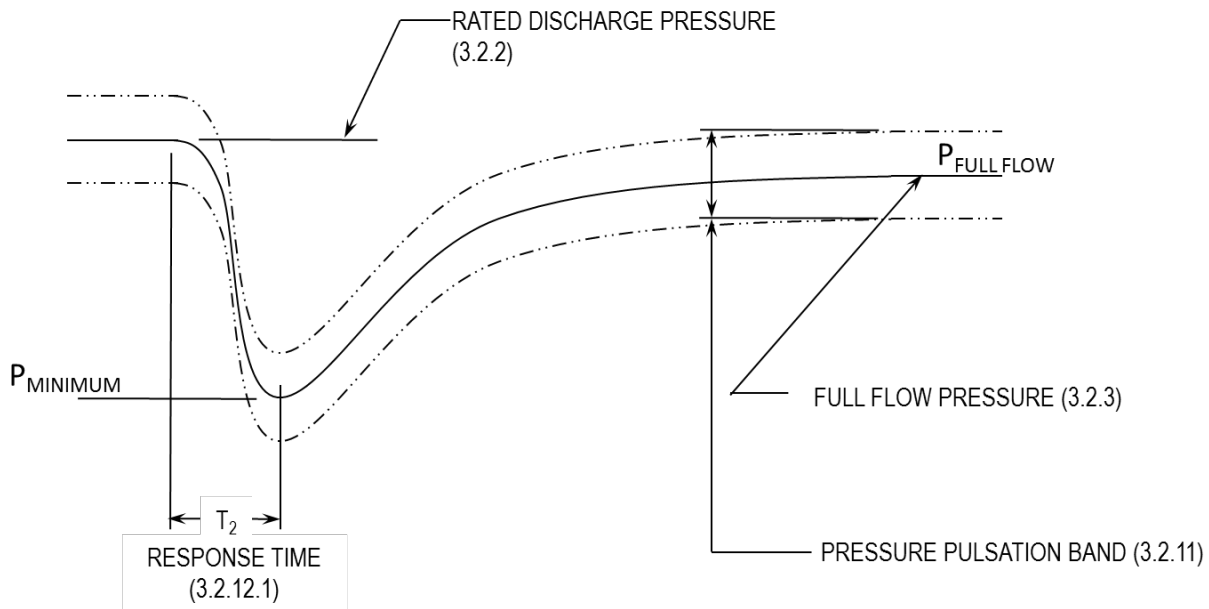


**Figure 3 - Typical pressure transient zero flow to full flow**

**STABILITY:** The stability of the pump is the freedom from persistent or quasi-persistent oscillation or "hunting" of the delivery control mechanism at any frequency that can be traced to the pump delivery control means.

**SUPPLIER:** The Supplier is the organization that has the responsibility for the design, production, and qualification of the pump. Normally, the Purchaser would approve the Supplier for the design, development, and manufacture of these pumps.

### 3. REQUIREMENTS

#### 3.1 General

The general requirements of AS8775 for Type I and II hydraulic systems pumps and MIL-H-8890 for Type III system pumps apply with the exceptions and additions specified herein.

In case of a conflict between the requirements of this specification and applicable requirements of AS8775 or MIL-H-8890 as applicable, the requirements of this specification take precedence.

#### 3.2 Functional Requirements

##### 3.2.1 Hydraulic Fluid

The hydraulic fluid shall be as specified in AS5440 or the Procurement Specification.

##### 3.2.2 Rated Discharge Pressure

The design of the pump shall be such as to maintain rated discharge pressure at the following combination and range of conditions:

- a. From 100 °F (38 °C) to rated fluid temperature.
- b. From 50 to 100% of rated speed and specified over speed at rated inlet pressure and zero flow using the hydraulic fluid specified in the Procurement Specification.