SAE Aerospace
An SAE International Group

AEROSPACE INFORMATION REPORT

SAE AIR1362 REV. B

Issued 1975-05
Revised 2000-08
Reaffirmed 2008-07

Superseding AIR1362A

Aerospace Hydraulic Fluids Physical Properties

SAENORM.COM : Click to view the full PDF of air1362b

1. SCOPE:

This SAE Aerospace Information Report (AIR) presents data on hydraulic fluids which are of interest to detail designers of hydraulic systems and components for aerospace flight vehicles. The data pertain to fluids conforming to specifications MIL-H-5606, MIL-H-8446, MIL-PRF-27601, MIL-PRF-83282, MIL-H-53119, MIL-PRF-87257, Aerospace Standard 1241 Type IV, Classes 1 and 2, and Type V. The relative merits of hydraulic fluid properties in relation to the fluid formulation, aerospace hydraulic system design and the related materials compatibility are discussed in AIR81, Hydraulic Fluid Properties. This document is essentially a metric document with English units available in the data charts for convenience. There is a treatment of conversions between ISO and English units in AIR1657.

2. 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 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 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AIR81A	Hydrocarbon-Based Hydraulic Fluid Properties
AIR1657A	Handbook of Hydraulic Metric Calculations
AS1241C	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2008 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-5606	Military Specification Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance, NATO Code Number H-515 (Inactive for New Design)
MIL-H-8446	Military Specification Hydraulic Fluid, Nonpetroleum Base; Aircraft (Canceled)
MIL-PRF-27601	Performance Specification Hydraulic Fluid, Fire Resistant, Hydrogenated Polyalphaolefin Base, High Temperature, Flight Vehicle, Metric
MIL-PRF-83282	Performance Specification Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Metric, NATO Code Number H-537
MIL-H-53119	Performance Specification Hydraulic Fluid, Nonflammable, Chlorotrifluoroethylene Base (Inactive for New Design)
MIL-PRF-87257	Military Specification Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile, NATO Code Number H-538

3. DESCRIPTION OF PROPERTIES:

3.1 Hydraulic fluids have many physical and chemical properties which must be considered in the design of a hydraulic system as follows:

TABLE 1

Property	Effect
1. Bulk Modulus	System stiffness
2. Viscosity	Power losses
3. Density	System weight
4. Specific Heat	Thermal characteristics
5. Thermal Conductivity	Heat exchanger design
6. Thermal Expansion	Reservoir design
7. Fire Resistance	Safety and survivability
8. Chemical Stability	Formation of breakdown products
9. Thermal Stability	Deterioration of fluid properties
10. Shear Stability	Loss of lubricity and viscosity
11. Hydrolytic Stability	Corrosion
12. Lubricity	Component wear
13. Compatibility	System materials
14. Volatility	Cavitation and evaporation
15. Toxicity	Safety
16. Foaming	Cavitation and system stiffness

SAENORM.COM : Click to view the full PDF of air1362b

3.1 (Continued):

NOTE: The above listing sequence has no bearing on relative importance. Properties 1 through 7 have specific numerical values which are required in detail design and analysis work; data covering these properties are given in the document. Properties 8 through 16 are important considerations in the selection of a hydraulic fluid for a specific application, but numerical values associated with these properties are not usually required in system design.

The types of hydraulic fluid considered to be most applicable to air vehicles are:

TABLE 2

Fluid Type	Operating Temperature	Specification
Petroleum base with polymeric additives	-54 to 135 °C	MIL-H-5606
Silicate ester	-54 to 204 °C	MIL-H-8446 (Canceled)
Synthetic hydrocarbon fire resistant	-40 to 288 °C	MIL-PRF-27601
Synthetic hydrocarbon, fire resistant	-40 to 205 °C	MIL-PRF-83282
Nonflammable, chloro-trifluoroethylene base	-54 to 135 °C	MIL-H-53119
Synthetic hydrocarbon, fire resistant	-54 to 135 °C	MIL-PRF-87257
Phosphate ester, fire resistant	-54 to 107 °C	AS1241, Type IV, Classes 1 and 2
	-54 to 135 °C	AS1241, Type V

SAENORM.COM : Click to view the full PDF of air1362b

NOTE: AS1241, Type IV phosphate ester fluid is used in two different versions, Class 1, a low density (specific gravity 0.990 to 1.020), and Class 2, a high density (specific gravity 1.020 to 1.066). Type V phosphate ester is a higher temperature fluid, with specific gravity 0.97 to 1.02. Where available, data for both classes and types are provided.

3.2 Operating conditions can cause changes in the physical properties of a hydraulic fluid. Temperature andn pressure, in particular, have significant influences on fluid viscosity and bulk modulus. The detail designer requires data for specific operating conditions, but these data are often not readily available. This results in designers acquiring, through various means, a personal file of hydraulic fluid properties. The intent of this document is to encourage the use of standardized design information. Fluid specifications provide for variations in properties which can result from diferences in manufacturing processes or base stocks used. The data presented herein are considered to be nominal values.

4. HYDRAULIC FLUID PROPERTIES:

4.1 Bulk Modulus:

Bulk modulus is a term used to denote the ability of a fluid to resist volumetric reduction caused by applied pressure and is an important parameter in the design of hydraulic servo systems. Interaction of fluid compressibility with the mass of the mechanical parts and load produces a natural frequency in hydraulic systems. This resonance is often the chief limitation to dynamic performance and is approximately proportional to the square root of the fluid bulk modulus. Pressure is generally measured as gauge pressure while all equations in this document use absolute pressure.

4.1.1 There are several different types of bulk moduli; selection of the proper modulus is based on the function being performed. Functions that occur rapidly, with little chance for heat transfer into or out of the system, require adiabatic moduli; examples include hydraulic pumps, motors, and rapidly oscillating servo actuators. Functions that occur slowly or with constant fluid temperature require isothermal moduli; this modulus has limited application to air vehicle hydraulic systems. Pressure excursion magnitude is also a factor in modulus selection. Large excursions, for example in pumps and motors, require the use of secant moduli; small pressure fluctuations around a quiescent level, as in oscillating servo actuators, require the use of tangent moduli. Bulk modulus is the reciprocal of fluid compressibility and is generally expressed in Pascal (Pa). The most commonly used moduli are summarized below:

SAENORM.COM : Click to view the full PDF of air1362b

TABLE 3

Function	Pressure Excursion	Bulk Modulus	Application
Dynamic	Small[1]	Adiabatic tangent	Design of servo systems and actuators
Dynamic	Large[2]	Adiabatic tangent	Design of hydraulic pumps
Static	Small	Isothermal tangent	Limited use in air vehicle system design
Static	Large	Isothermal secant	Limited use in air vehicle systems design

[1] Less than 10% of system pressure (approximately).
[2] More than 80% of system pressure (approximately).

SAENORM.COM : Click to view the full PDF of air1362b

4.1.2 Bulk modulus is defined by:

$$\beta_t = -V \frac{\partial P}{\partial V} \quad \text{(Eq. 1)}$$

and,

$$\beta_s = -V_o \left(\frac{P_o - P}{V_o - V}\right) \quad \text{(Eq. 2)}$$

where:

β_t = Adiabatic tangent bulk modulus, Pa
β_s = Adiabatic sectant bulk modulus, Pa
P = Pressure, Pa
V = Volume at pressure P, m^3
P_o = Reference pressure, usually atmospheric, Pa
V_o = Volume at pressure P_o, m^3

4.1.2 (Continued):

Equation 1 is the thermodynamic definition of bulk modulus and represents the true rate of volumetric change at the pressure of "interest". Equation 2 defines a "mean" bulk modulus and represents the volumetric change with pressure from atmospheric to the pressure of "interest". Both moduli can be determined under isothermal or adiabatic conditions.

Two methods used for measuring bulk modulus are the pressure-volume-temperature method, which gives isothermal secant information and the sonic method which yields adiabatic tangent data. Relationships between the moduli are:

$$\frac{\beta_{at}}{\beta_{it}} = \gamma$$

β_{it} at pressure P is approximately equal to β_{is} at pressure 2P (Eq. 3)

$$\beta_{at} = \rho c^2$$

where:

β_{at} = Adiabatic tangent bulk modulus, Pa
β_{it} = Isothermal tangent bulk modulus, Pa
β_{is} = Isothermal secant bulk modulus, Pa
$\gamma = \frac{c_p}{c_v}$
c_p = Specific heat at constant pressure, J/(kg K)
c_v = Specific heat at constant volume, J/(kg K)
ρ = Fluid mass density, kg/m^3
c = Velocity of sound in the fluid, m/s

Bulk modulus can be substantially lowered by the presence of entrained air (free bubbles) in the fluid. Dissolved air has a minor effect in reducing bulk modulus. The amount of air which can be dissolved in hydraulic fluids is approximately proportional to the pressure level. The time required to achieve equilibrium conditions may prevent complete dissolution in some cases. Generally, when the operating pressure exceeds the saturation pressure, bulk modulus degradation due to air is small.

SAENORM.COM : Click to view the full PDF of air1362b

4.1.3 The bulk modulus data presented in this document cover temperatures from +38 to +149 °C at pressure from 0 to 55 mega Pascal (MPa).

TABLE 4

Figure No.	Bulk Modulus	Hydraulic Fluid
1	adiabatic tangent	MIL-H-5606
2		MIL-H-8446
3		MIL-PRF-27601
4		MIL-PRF-83282
5		MIL-H-53119
6		MIL-PRF-87257
7		AS1241, Type IV, Class 1
8	adiabatic secant	MIL-H-5606
9		MIL-H-8446
10		MIL-PRF-27601
11		MIL-PRF-83282
12		MIL-PRF-87257
13	isothermal secant	MIL-H-5606
14		MIL-H-8446
15		MIL-PRF-27601
16		MIL-PRF-83282
17		MIL-H-53119
18		MIL-PRF-87257
19		AS1241, Type IV, Class 1

SAENORM.COM : Click to view the full PDF of air1362b

4.2 Viscosity:

Viscosity causes a fluid to resist flow, varies with ambient condition and contributes to characterizing flow as laminar or turbulent. Fluid viscosity nearly always limits the lowest operating temperature of a hydraulic system and often limits the highest operating temperature. Fluid systems and components have conflicting viscosity requirements, i.e., good lubrication and low internal leakage require a moderately high viscosity while low line losses and fast control response dictate a low viscosity fluid. Good design requires a thorough consideration of the effects of operating conditions on viscosity and the efect of viscosity variations on system performance.

4.2.1 Fluid flow causes shear stresses within the fluid which vary with the velocity gradient across a given sheared section. For Newtonian fluids the shear stress is proportional to the velocity gradient across a given sheared section. For the non-Newtonian fluids the shear stress is not proportional to the velocity gradient.

The shear equation for Newtonian fluids is as follows:

$$\tau = \mu \frac{du}{ds} \quad \text{(Eq. 4)}$$

where:

τ = Shear stress, Pa
μ = Absolute viscosity, Pa s
$\frac{du}{ds}$ = Velocity gradient across sheared section of thickness ds, s^{-1}

Many models have been proposed for the shear equation for non-Newtonian fluids. In general some of these equations can be written as:

$$\frac{\partial u}{\partial s} = \frac{\tau}{\mu}\left[1 - \left(\frac{\tau}{\tau_L}\right)^n\right]^{-1/n} \quad \text{(Eq. 5)}$$

where:

n depends on the model chosen
τ_L = Limiting-shear-strength of fluid, Pa

4.2.2 The ratio of absolute viscosity to fluid mass density occurs frequently in flow analyses. This ratio is, by definition, the kinematic viscosity of the fluid.

$$\upsilon = \frac{\mu}{\rho} \quad \text{(Eq. 6)}$$

where:

υ = Kinematic viscosity, mm^2/s or centi-Stoke (cSt)
μ = Absolute viscosity, mPa.s or cP (centi-Poise)
ρ = Mass density, g/cm^3

Kinematic viscosity at atmospheric pressure is easily measured with commercially available viscometers. Kinematic viscosity has units of cm^2/s called Stokes. Because this unit is large, the term centistoke (cSt) is often used.

SAENORM.COM : Click to view the full PDF of air1362b

4.2.2 (Continued):

The viscosity of hydraulic fluids decreases significantly as temperature is increased. This relationship can be plotted using ASTM viscosity graph paper resulting in a straight line plot or approximated by:

$$\mu_T = \mu_o e^{-\lambda(T-T_o)} \quad \text{(Eq. 7)}$$

where:

μ_T = Absolute viscosity at Temperature T, Pa s
μ_o = Viscosity at reference temperature T_o, Pa s
λ = A temperature-viscosity coefficient which depends upon the fluid, 1/°C
T = Temperature, °C

Viscosity increases as pressure is increased. This relationship can be approximated by the Barus equation:

$$\mu_P = \mu_o e^{\alpha P} \quad \text{(Eq. 8)}$$

where:

μ_P = Absolute viscosity at pressure P, Pa s
μ_o = Viscosity at atmospheric pressure, Pa s
α = Pressure-viscosity coefficient which varies with temperature, Pa^{-1}
P = Pressure, Pa

4.2.3 Hydraulic fluids employing viscosity-index improvers, i.e., MIL-H-5606 and AS1241 undergo permanent viscosity loss when the fluid is subjected to high shear rates. On the other hand, the fluids not containing the viscosity-index improvers do not exhibit this phenomenon.

Generally accepted viscosity levels for air vehicle hydraulic systems are:

SAENORM.COM : Click to view the full PDF of air1362b

TABLE 5

Condition	Viscosity, cSt	Remarks
Cold start	2500 maximum	Operation at reduced rate permitted
Maximum operating viscosity	500	Rated system performance required
Optimum performance	1 to 10	Maximum component efficiency and life

4.2.3 (Continued):

The viscosity (mm^2/s or cSt) in the document cover temperatures from -46 to 205 °C at pressures from 0 to 55 MPa.

TABLE 6

Figure No.	Plot	Hydraulic Fluid
20	Viscosity versus Pressure	MIL-H-5606
21		MIL-H-8446
22		MIL-PRF-27601
23		MIL-PRF-83282
24		MIL-H-53119
25		MIL-PRF-87257
26		AS1241, Type IV, Class 1, Class 2
27	Viscosity versus Temperature	MIL-H-5606
28		MIL-H-8446
29		MIL-PRF-27601
30		MIL-PRF-83282
31		MIL-H-53119
32		MIL-PRF-87257
33		AS1241, Type IV, Class 1, Class 2

SAENORM.COM : Click to view the full PDF of air1362b

4.3 Density:

Fluid density is an important factor in calculations made to estimate hydraulic system weight and is required in analyses involving Reynolds number, bulk modulus and orifice flow. Line losses and heat generation are directly proportional to fluid density. Temperature and pressure have moderate effects on density. Fluid mass density and specific weight are related as follows:

$$\rho = \frac{w}{g} \quad \text{(Eq. 9)}$$

where:

ρ = Mass density (mass per unit volume), kg/m^3
w = Specific weight (weight per unit volume), N/m^3
g = Acceleration due to gravity, m/s^2

4.3 (Continued):

The mass density (g/cm^3) data in the document cover temperatures from 38 to 149 °C at pressures from 0 to 55 MPa gauge.

TABLE 7

Figure No.	Hydraulic Fluid
34	MIL-H-5606
35	MIL-H-8446
36	MIL-PRF-27601
37	MIL-PRF-83282
38	MIL-H-53119
39	MIL-PRF-87257 (atmospheric pressure only)
40	AS1241, Type IV (atmospheric pressure only) Class 1, Class 2

SAENORM.COM : Click to view the full PDF of air1362b

4.4 Specific Heat:

Heat is generated in hydraulic systems principally by fluid compression, pump inefficiencies, transmission line friction, pressure drops across orifices and internal leakage in valves on output devices. Fluid specific heat is required in thermal analyses involving heat transfer, heating and cooling rates, and temperature build-up.

The specific heat of a liquid is the amount of heat required to raise the temperature of a unit mass by 1° and is expressed in cal/(gm°C). The specific heat at constant pressure (c_p) increases with rise in temperature; pressures from 0 to 69 MPa gauge have little effect on c_p. The specific heat at constant volume is shown as c_v.

The specific heat ratio $\frac{c_p}{c_v}$ is useful in calculations related to bulk modulus. The specific heat ratio generally decreases with increasing temperature; pressures in the range of 0 to 69 MPa gauge have little effect on the ratio.

Specific heat (J/kg °C) data in the document are at atmospheric pressure and cover temperatures from -18 to 205 °C.

TABLE 8

Figure No.	Property
41	Specific Heat of Hydraulic Fluids
42	Specific Heat Ratio of Hydraulic Fluids

4.5 Thermal Conductivity:

Fluid thermal conductivity is required in conduction-convection problems involving calculation of the surface film coefficient for heat exchanger design. Thermal conductivity is a measure of the rate of heat flow through the fluid. The thermal conductivity of most liquids decreases with increases in temperature and changes only slightly with pressure. Thermal conductivity (watt/m °C) data in the document are at atmospheric pressure and cover temperatures from -18 to +205 °C.

TABLE 9

Figure No.	Plot
43	Thermal Conductivity of Hydraulic Fluids

SAENORM.COM : Click to view the full PDF of air1362b

4.6 Coefficient of Thermal Expansion:

Hydraulic fluid expansion is of particular interest to the designer of a closed system which must operate over a wide temperature range. A low coefficient of expansion will minimize the capacity which must be added to accommodate increases in system fluid volume caused by rising temperatures. The coefficient of thermal expansion is related to fluid density. Temperature and pressure have relatively small effects on the coefficient. The coefficient of thermal expansion values listed below are at atmospheric pressure and cover a temperature range from +38 to +300 °C and are expressed in $cm^3/(cm^3$ °C).

TABLE 10

Hydraulic Fluid	Coefficient of Thermal Expansion
MIL-H-5606	8.6×10^{-4}
MIL-PRF-27601	8.1×10^{-4}
MIL-PRF-83282	8.2×10^{-4}
MIL-H-53119	9.0×10^{-4}
MIL-PRF-87257	8.2×10^{-4}
AS1241 Type IV	
Class 1	9.2×10^{-4}
Class 2	8.5×10^{-4}

4.7 Fire Resistance:

There are several measures of fire resistance used to characterize fire resistance, the most prevalent being flash point. Typical ASTM open cup values are shown below.

TABLE 11

Hydraulic Fluid	Flash Point
MIL-H-5606	102 °C
MIL-PRF-27601	205 °C
MIL-PRF-83282	220 °C
MIL-H-53119	None
MIL-PRF-87257	170 °C
AS1241 Type IV Class 1	171 °C
AS1241 Type IV Class 2	182 °C
AS1241 Type V	158 °C

SAENORM.COM : Click to view the full PDF of air1362b

PREPARED UNDER THE JURISDICTION OF
SAE SUBCOMMITTEE A-6C, FLUID POWER DISTRIBUTION
OF COMMITTEE A-6, AEROSPACE FLUID POWER ACTUATION
AND CONTROL TECHNOLOGIES

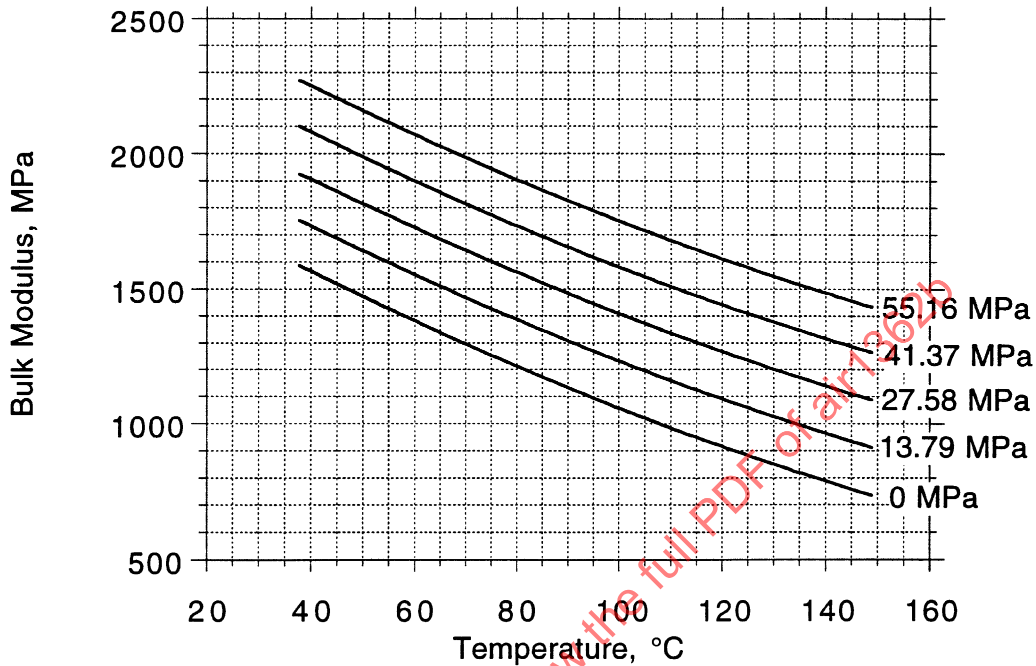

FIGURE 1A - Adiabatic Tangent Bulk Modulus of MIL-H-5606

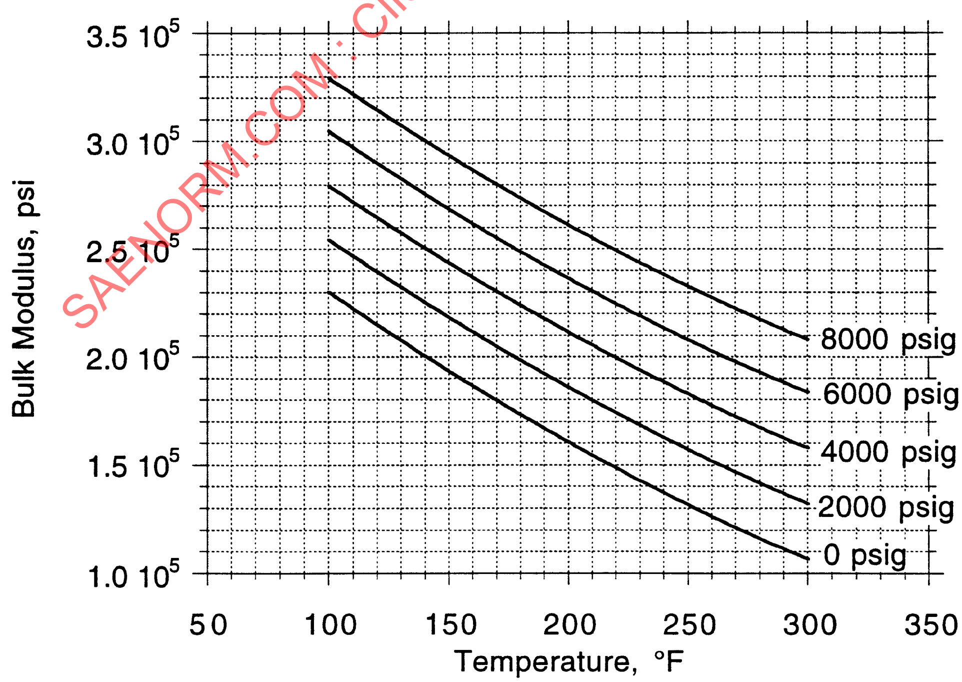

FIGURE 1B - Adiabatic Tangent Bulk Modulus of MIL-H-5606

SAENORM.COM : Click to view the full PDF of air1362b

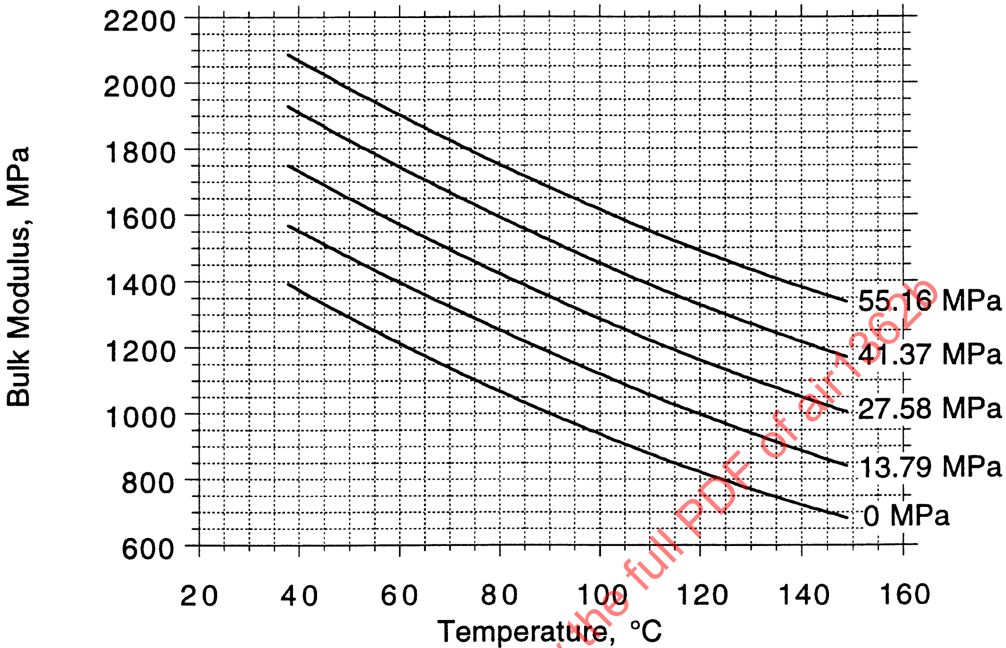

FIGURE 2A - Adiabatic Tangent Bulk Modulus of MIL-H-8446

SAENORM.COM : Click to view the full PDF of air1362b

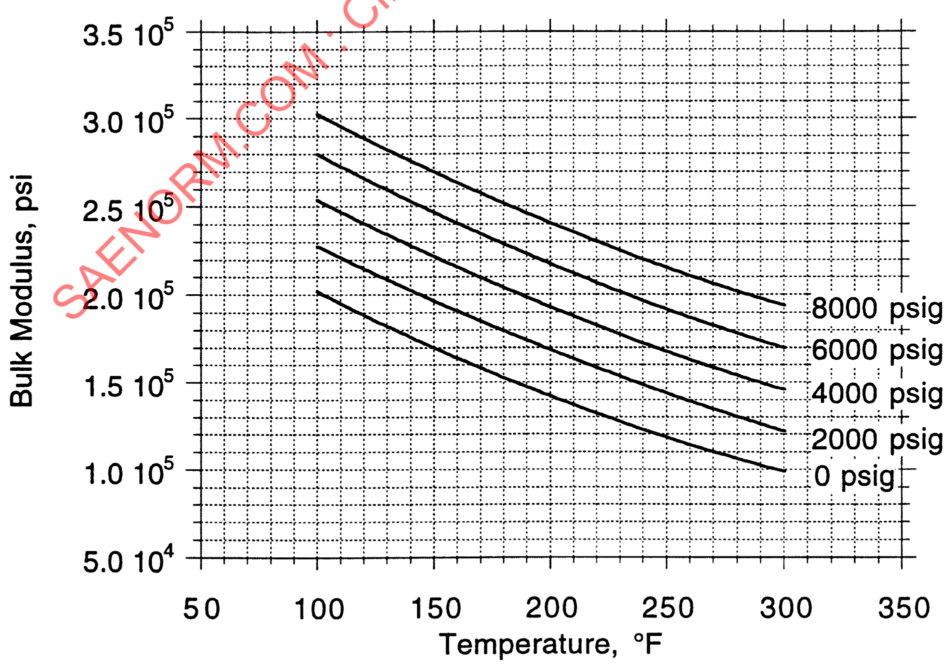

FIGURE 2B - Adiabatic Tangent Bulk Modulus of MIL-H-8446

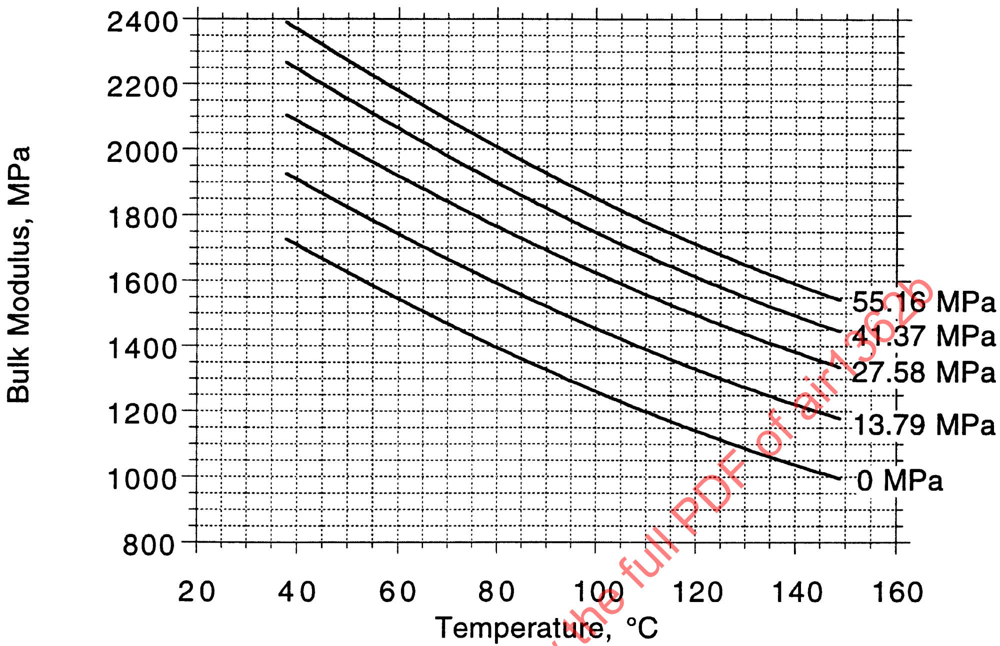

FIGURE 3A - Adiabatic Tangent Bulk Modulus of MIL-PRF-27601

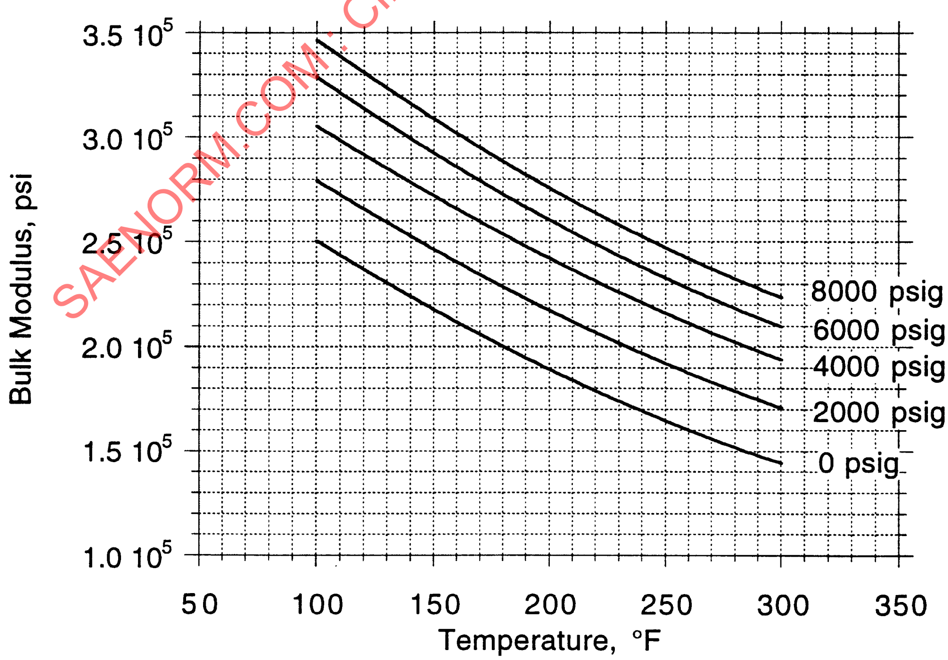

FIGURE 3B - Adiabatic Tangent Bulk Modulus of MIL-PRF-27601

SAENORM.COM : Click to view the full PDF of air1362b

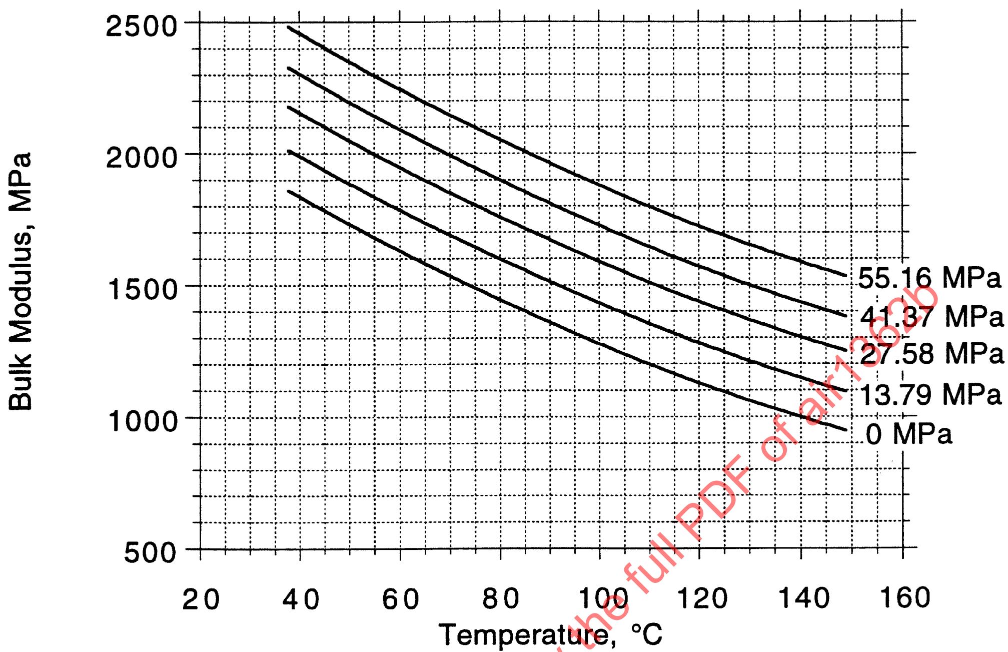

FIGURE 4A - Adiabatic Tangent Bulk Modulus of MIL-PRF-83282

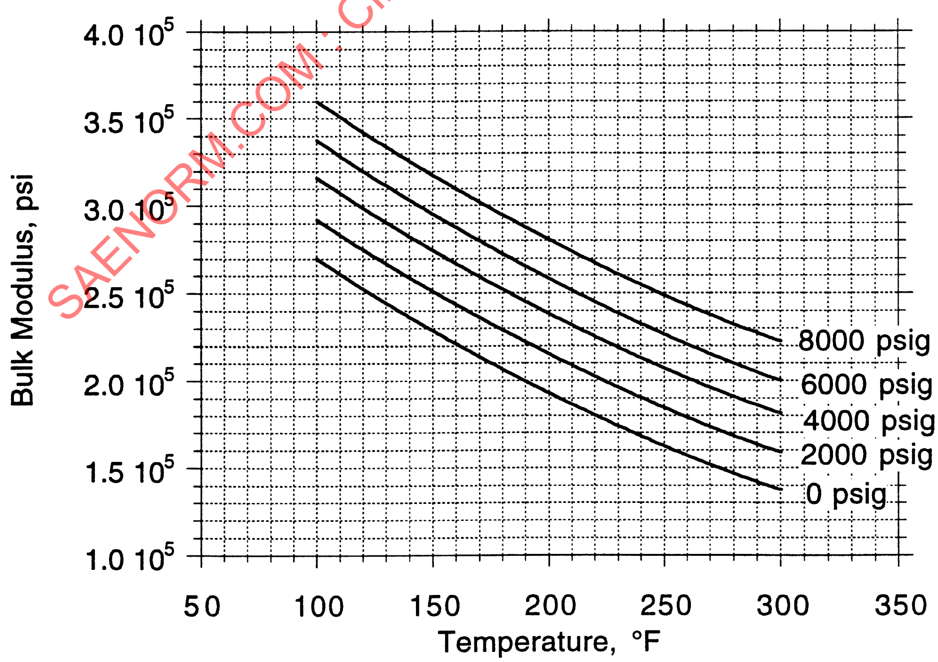

FIGURE 4B - Adiabatic Tangent Bulk Modulus of MIL-PRF-83282

SAENORM.COM : Click to view the full PDF of air1362b

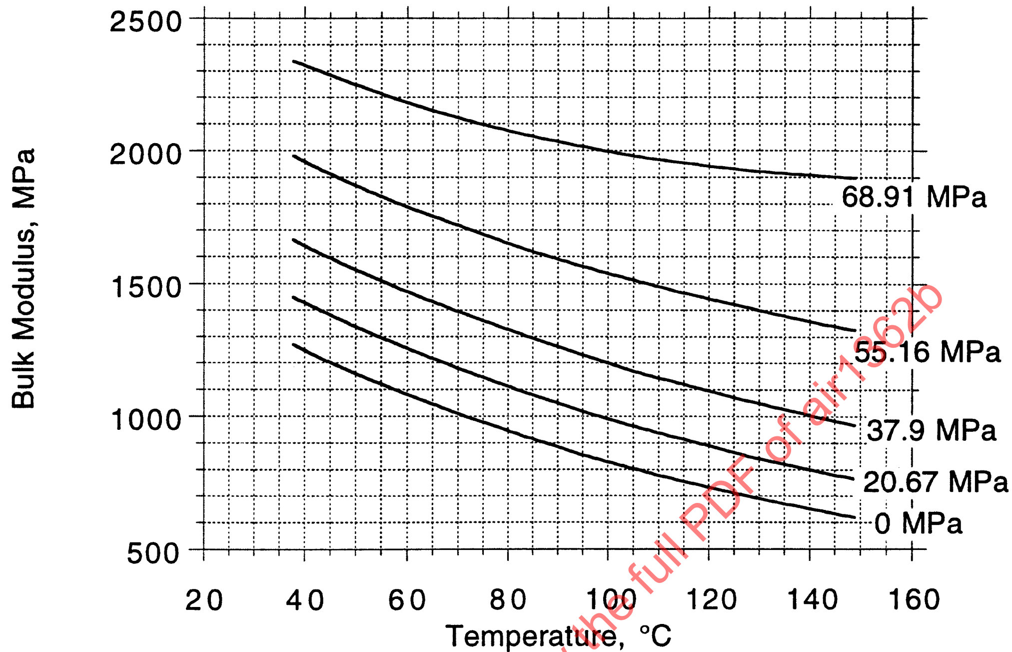

FIGURE 5A - Adiabatic Tangent Bulk Modulus of MIL-H-53119

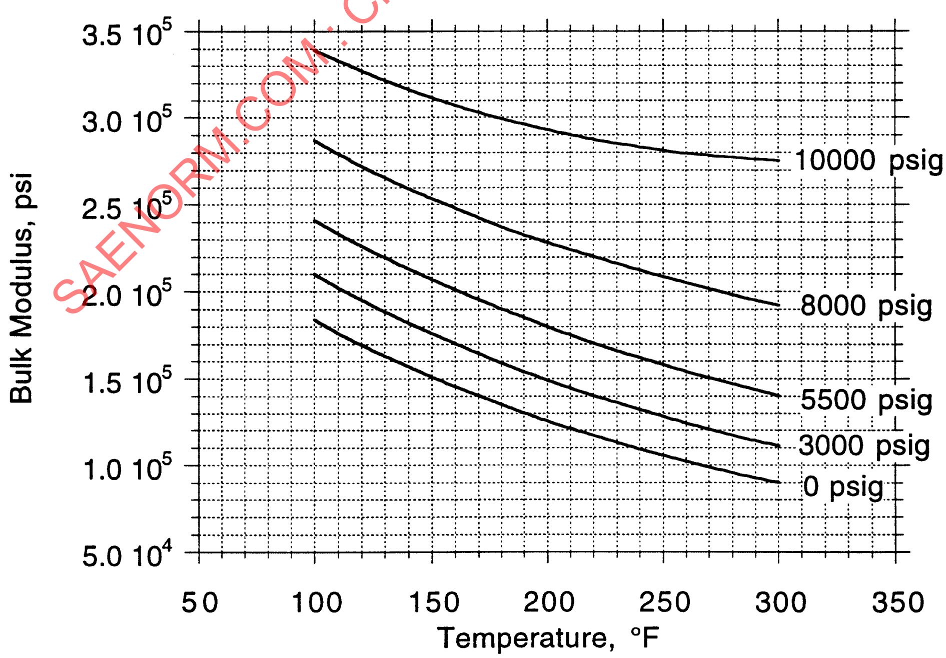

FIGURE 5B - Adiabatic Tangent Bulk Modulus of MIL-H-53119

SAENORM.COM : Click to view the full PDF of air1362b

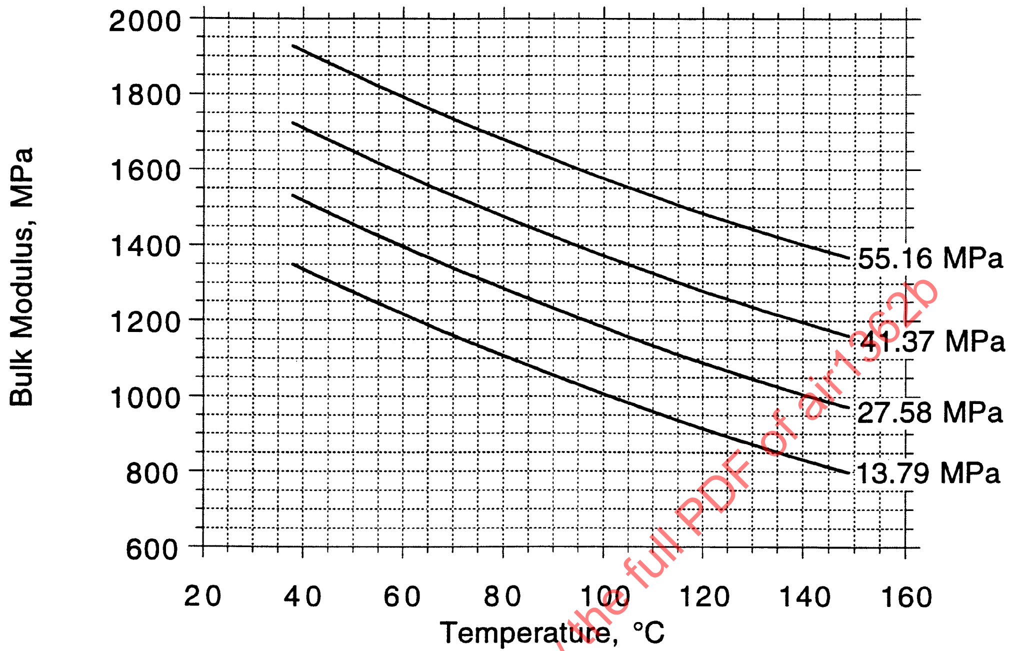

FIGURE 6A - Adiabatic Tangent Bulk Modulus of MIL-PRF-87257

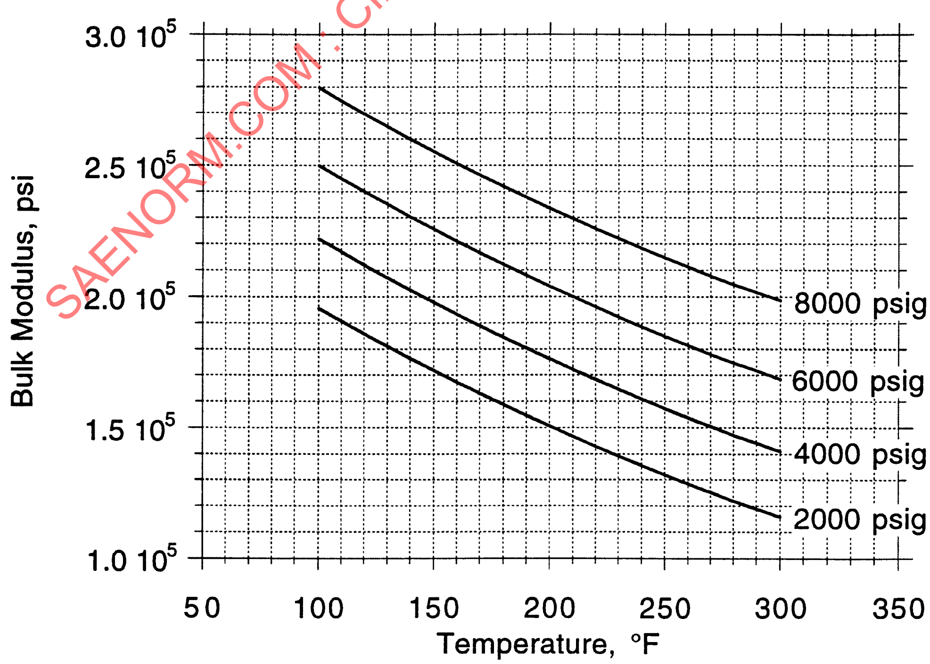

FIGURE 6B - Adiabatic Tangent Bulk Modulus of MIL-PRF-87257

SAENORM.COM : Click to view the full PDF of air1362b

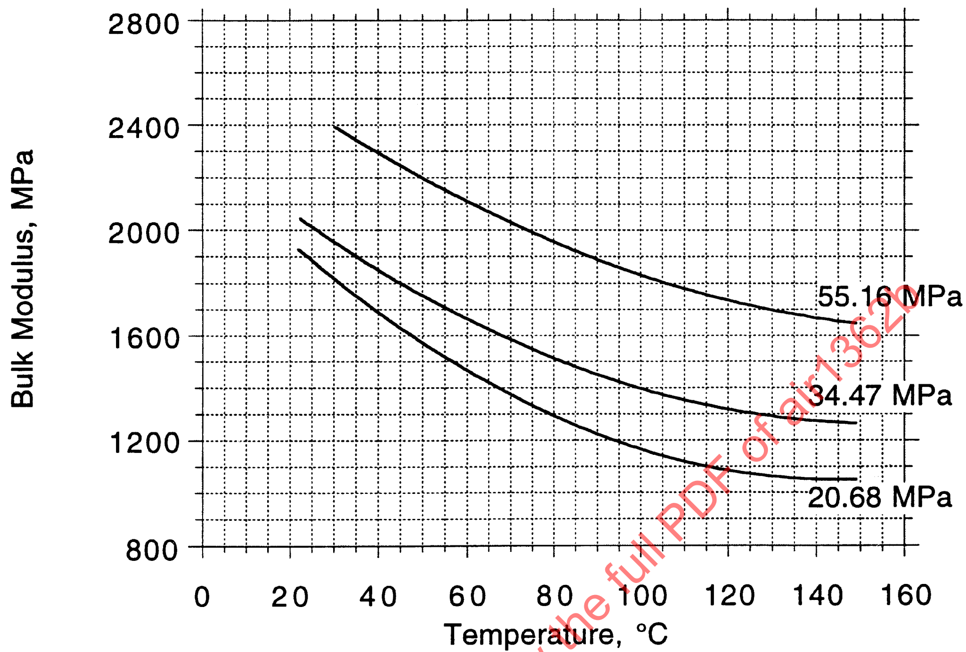

FIGURE 7A - Adiabatic Tangent Bulk Modulus of AS1241, Type IV, Class 1

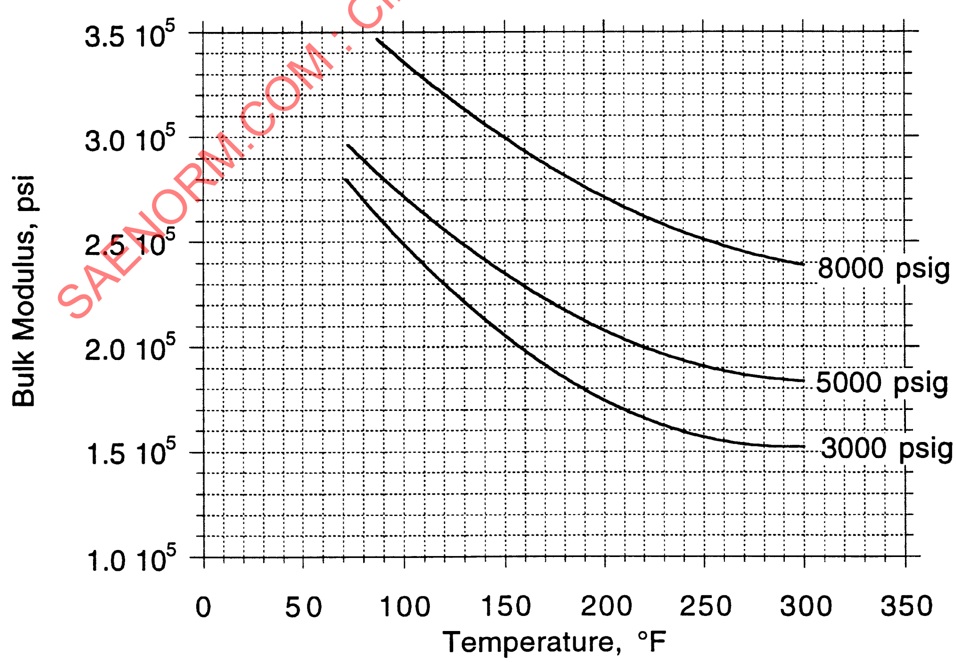

FIGURE 7B - Adiabatic Tangent Bulk Modulus of AS1241, Type IV, Class 1

SAENORM.COM : Click to view the full PDF of air1362b

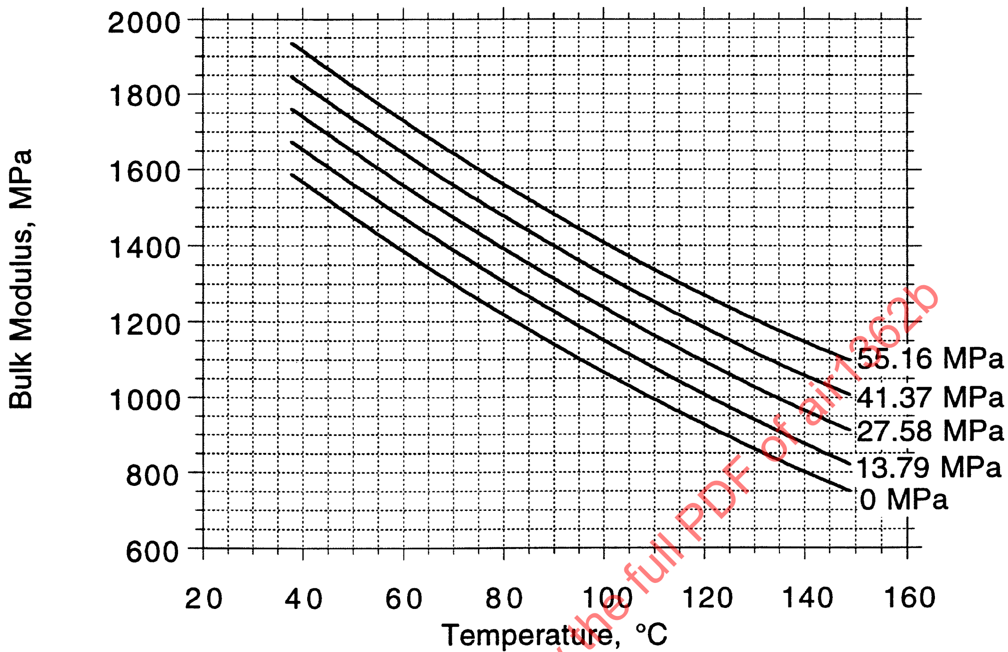

FIGURE 8A - Adiabatic Secant Bulk Modulus of MIL-H-5606

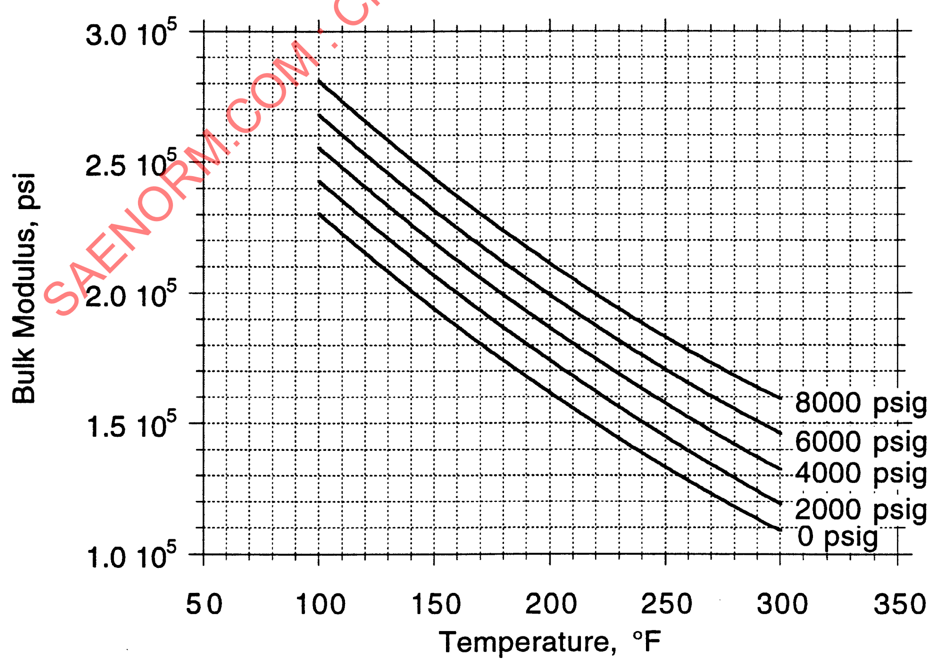

FIGURE 8B - Adiabatic Secant Bulk Modulus of MIL-H-5606

SAENORM.COM : Click to view the full PDF of air1362b

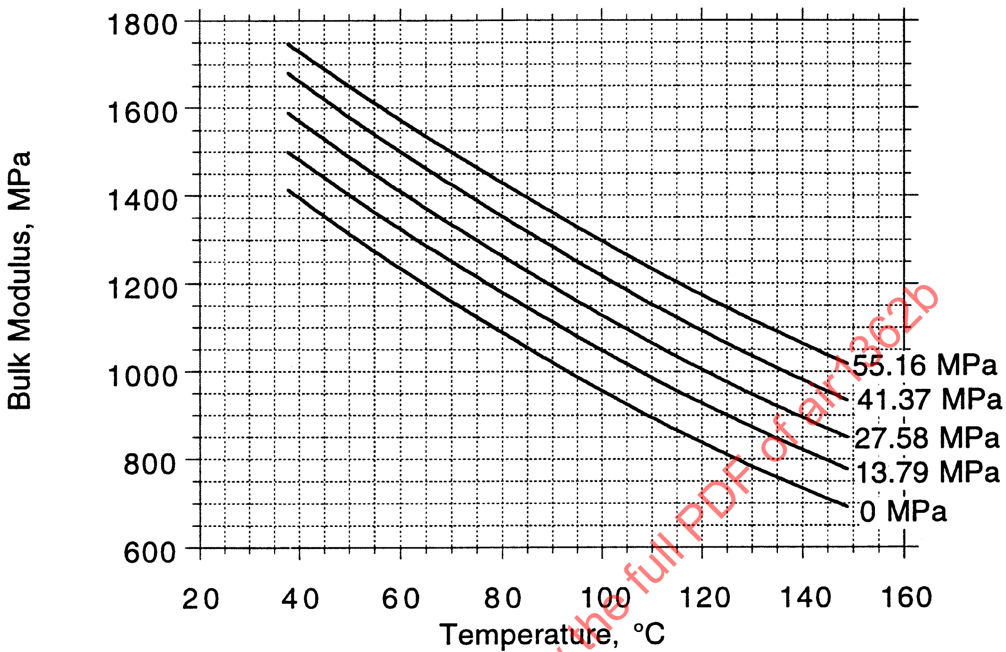

FIGURE 9A - Adiabatic Secant Bulk Modulus of MIL-H-8446

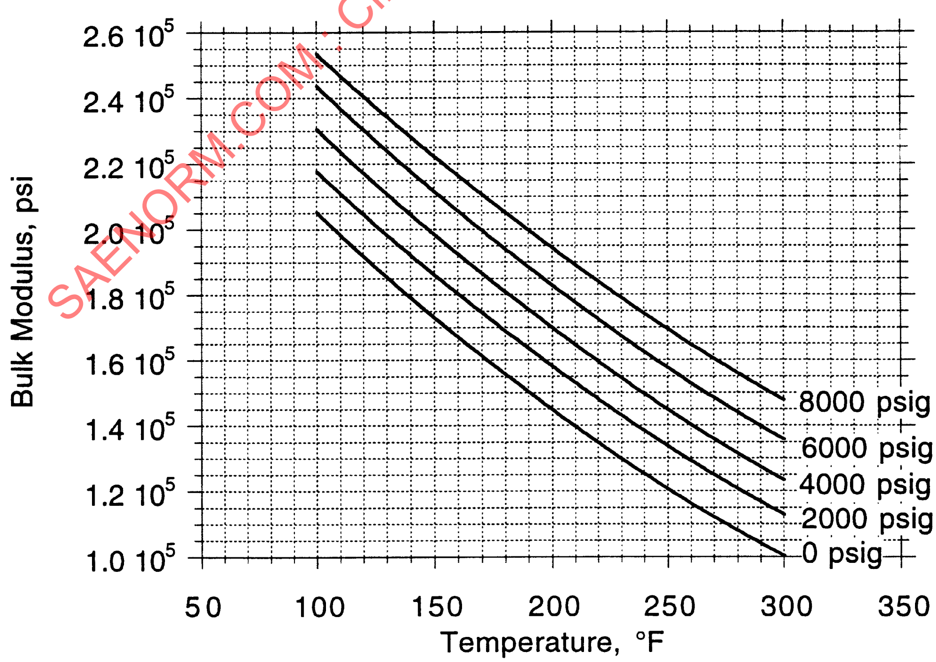

FIGURE 9B - Adiabatic Secant Bulk Modulus of MIL-H-8446

SAENORM.COM : Click to view the full PDF of air1362b

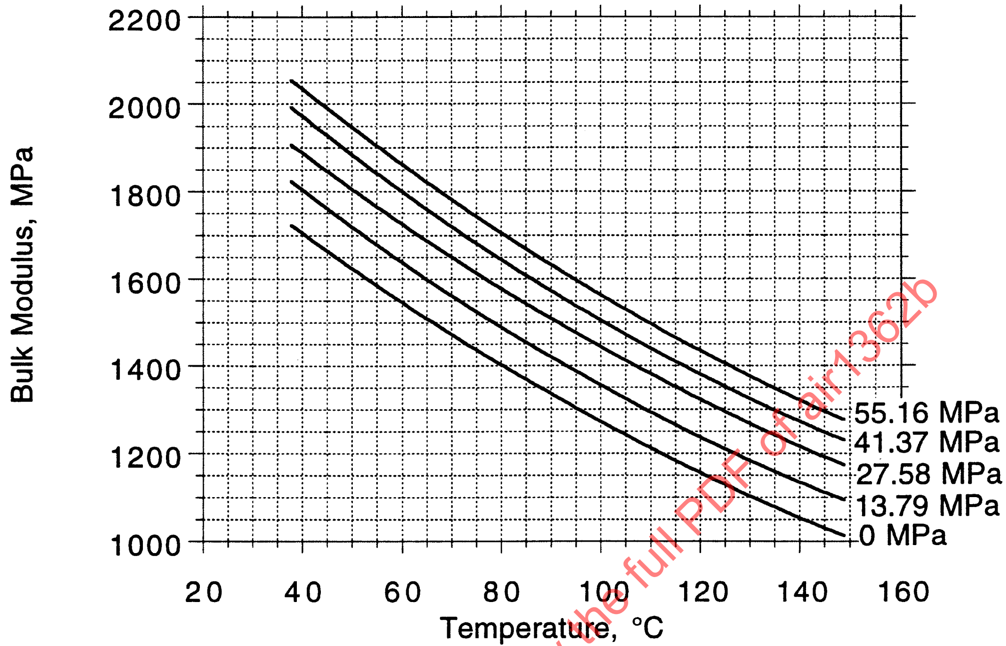

FIGURE 10A - Adiabatic Secant Bulk Modulus of MIL-PRF-27601

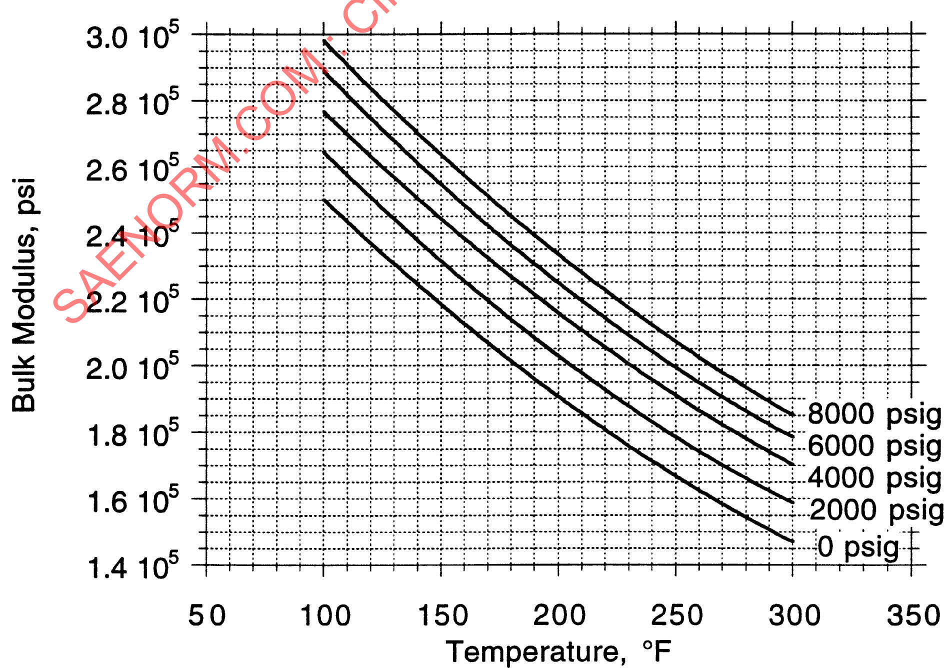

FIGURE 10B - Adiabatic Secant Bulk Modulus of MIL-PRF-27601

SAENORM.COM : Click to view the full PDF of air1362b

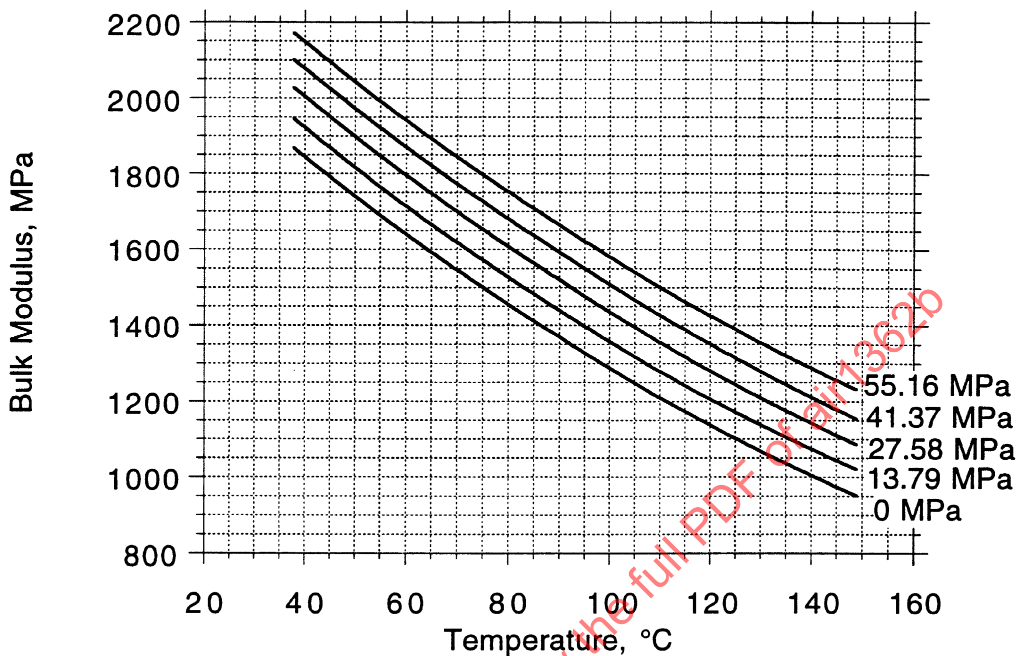

FIGURE 11A - Adiabatic Secant Bulk Modulus of MIL-PRF-83282

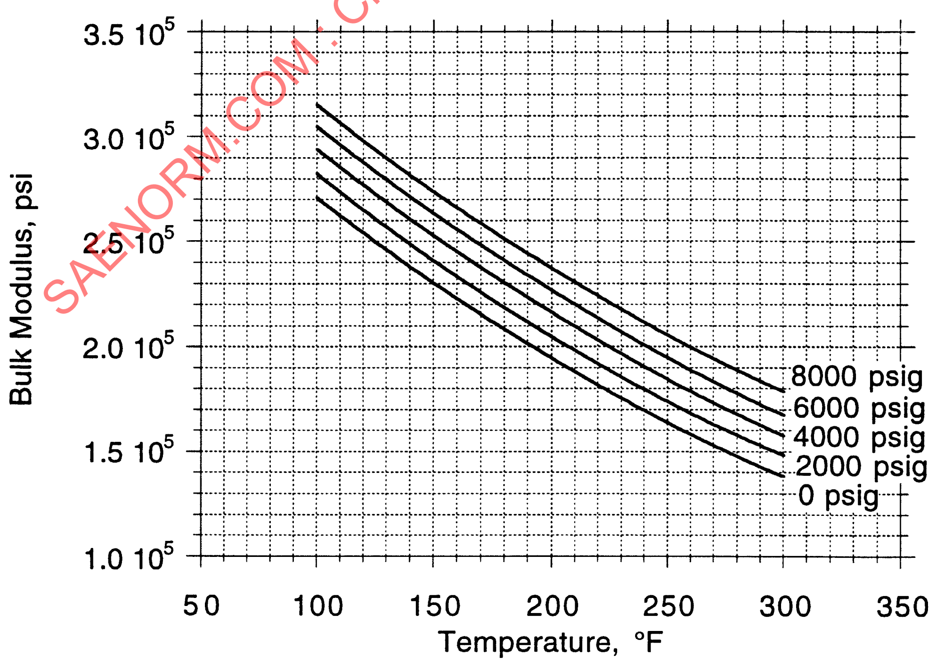

FIGURE 11B - Adiabatic Secant Bulk Modulus of MIL-PRF-83282

SAENORM.COM : Click to view the full PDF of air1362b

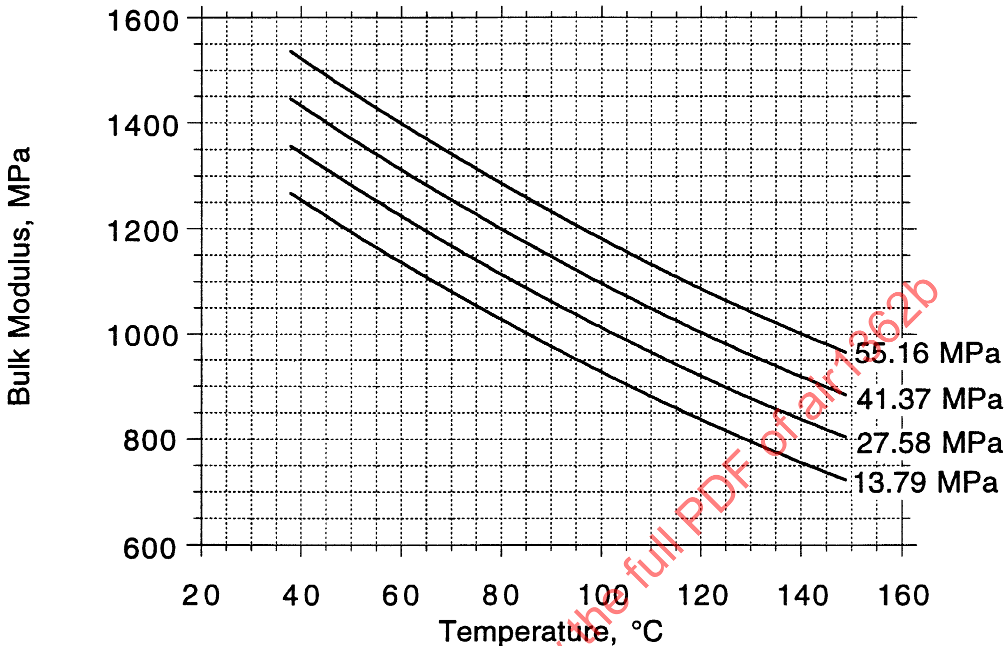

FIGURE 12A - Adiabatic Secant Bulk Modulus of MIL-PRF-87257

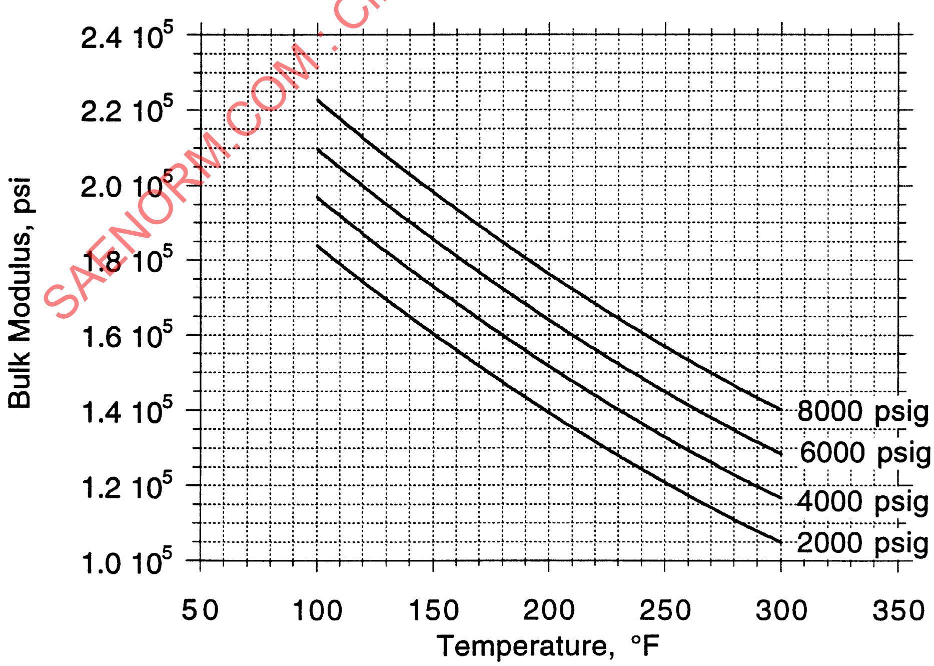

FIGURE 12B - Adiabatic Secant Bulk Modulus of MIL-PRF-87257

SAENORM.COM : Click to view the full PDF of air1362b

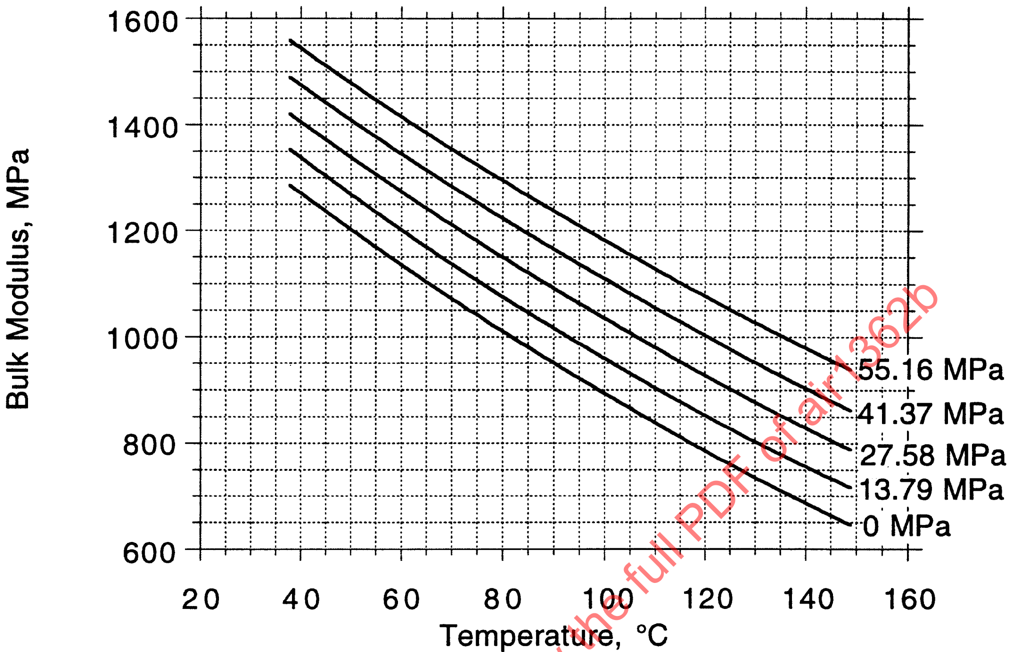

FIGURE 13A - Isothermal Secant Bulk Modulus of MIL-H-5606

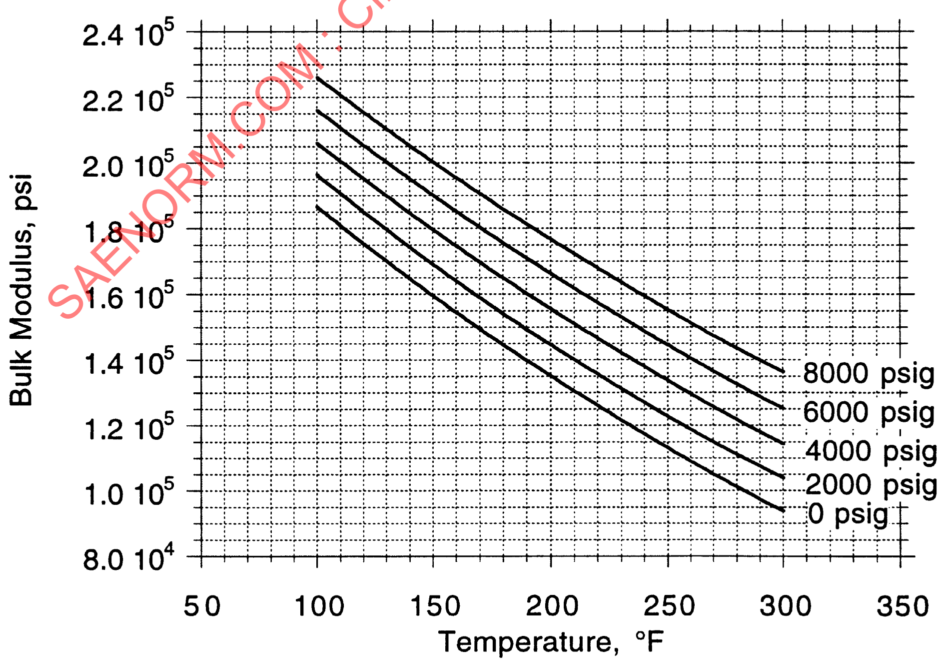

FIGURE 13B - Isothermal Secant Bulk Modulus of MIL-H-5606

SAENORM.COM : Click to view the full PDF of air1362b

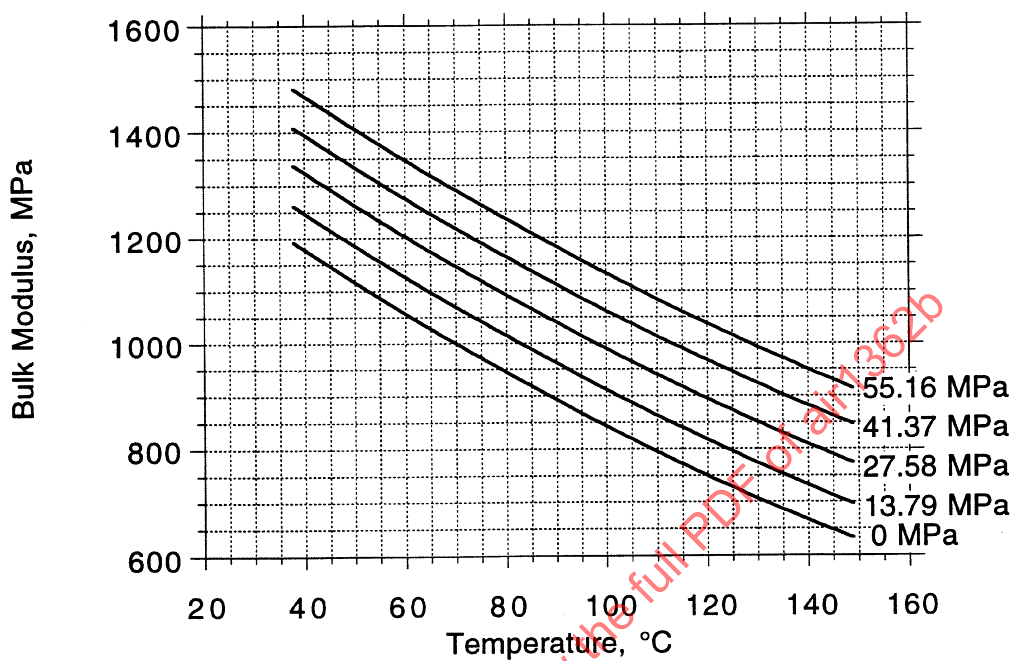

FIGURE 14A - Isothermal Secant Bulk Modulus of MIL-H-8446

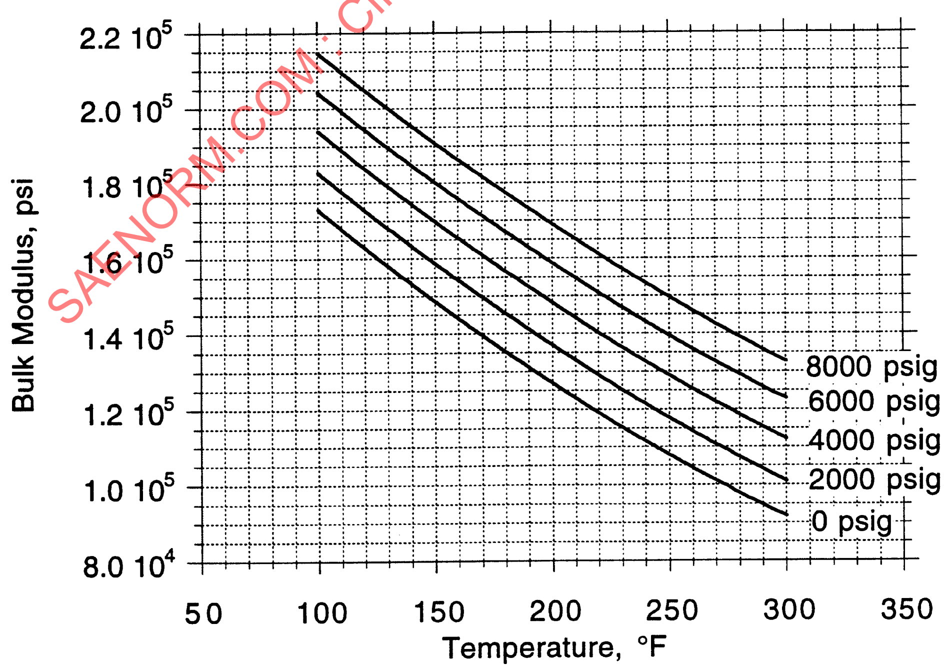

FIGURE 14B - Isothermal Secant Bulk Modulus of MIL-H-8446

SAENORM.COM : Click to view the full PDF of air1362b

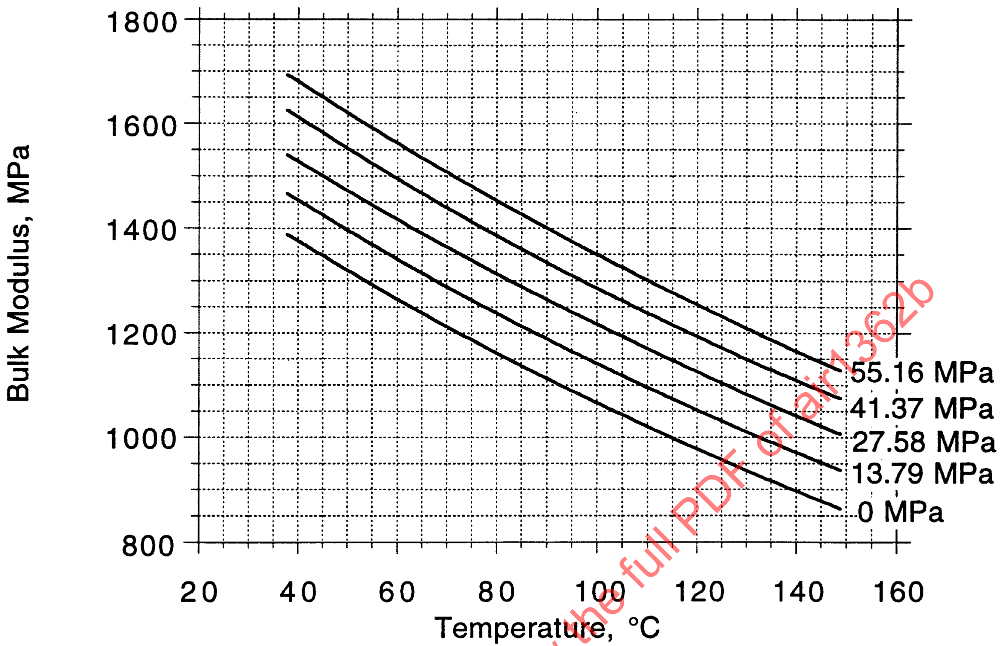

FIGURE 15A - Isothermal Secant Bulk Modulus of MIL-PRF-27601

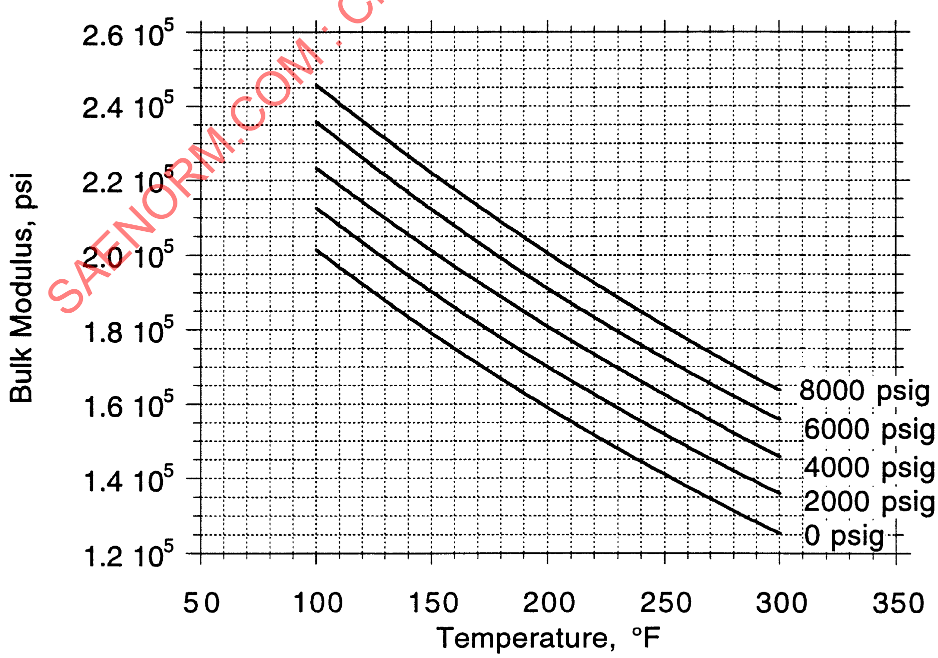

FIGURE 15B - Isothermal Secant Bulk Modulus of MIL-PRF-27601

SAENORM.COM : Click to view the full PDF of air1362b

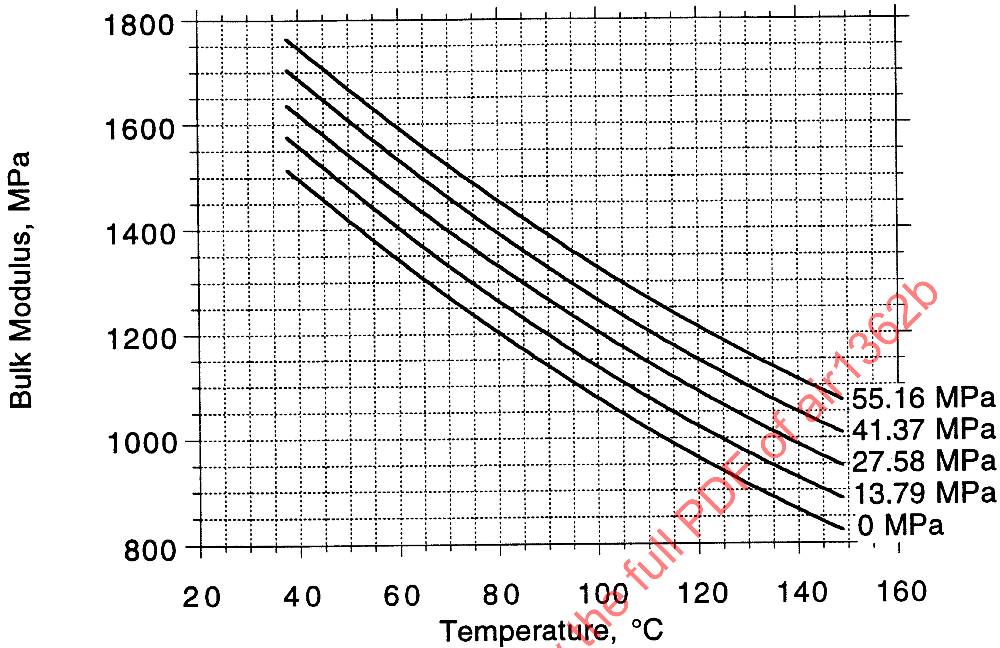

FIGURE 16A - Isothermal Secant Bulk Modulus of MIL-PRF-83282

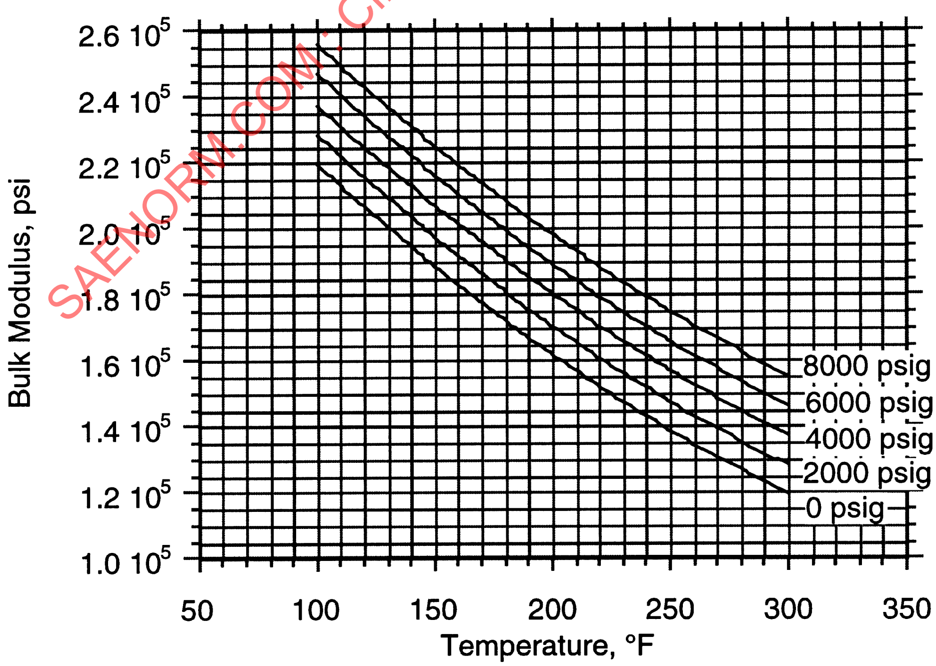

FIGURE 16B - Isothermal Secant Bulk Modulus of MIL-PRF-83282

SAENORM.COM : Click to view the full PDF of air1362b

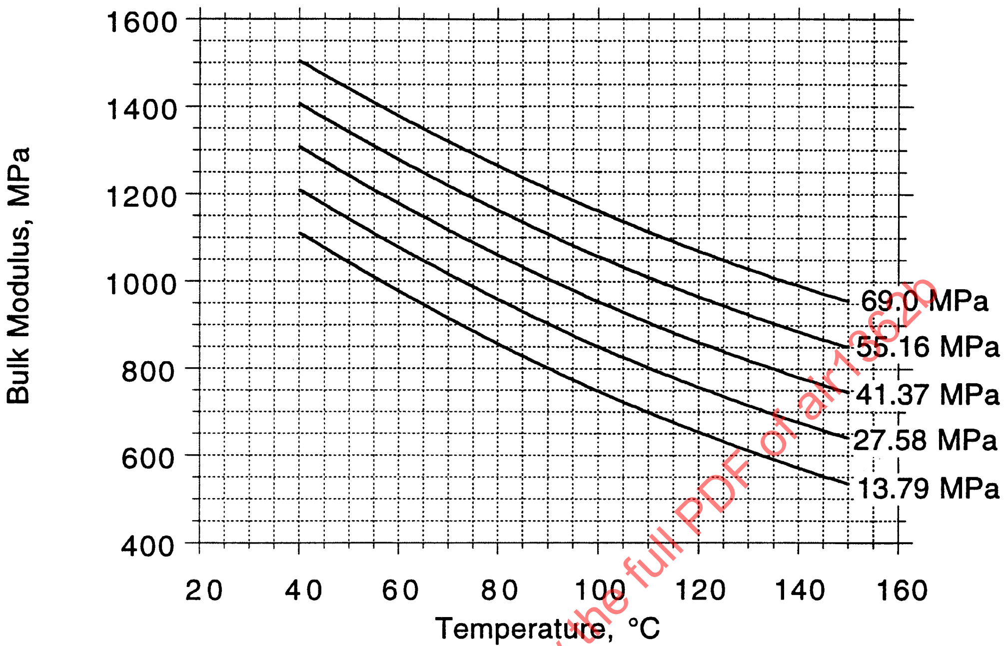

FIGURE 17A - Isothermal Secant Bulk Modulus of MIL-H-53119

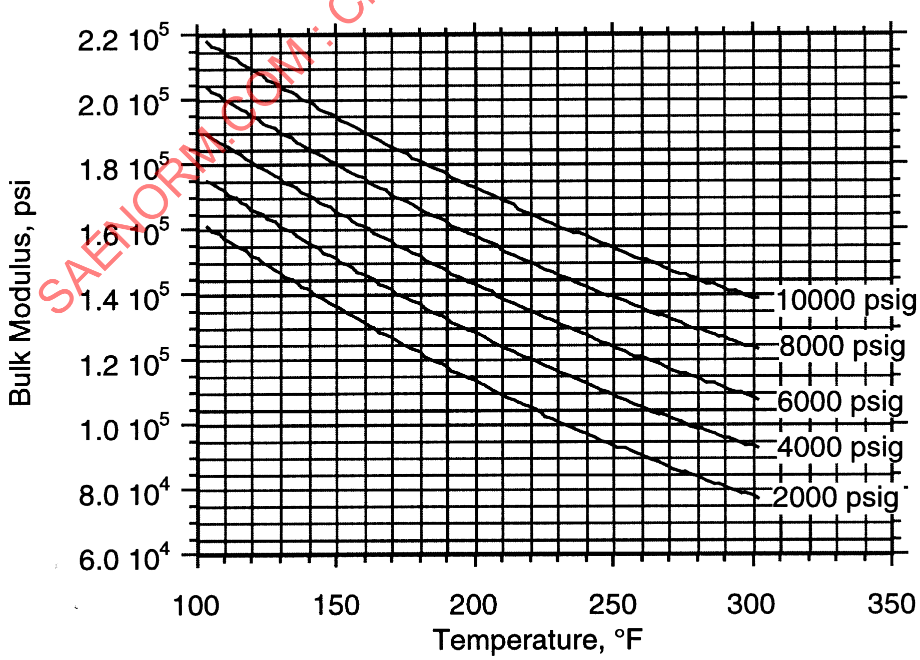

FIGURE 17B - Isothermal Secant Bulk Modulus of MIL-H-53119

SAENORM.COM : Click to view the full PDF of air1362b

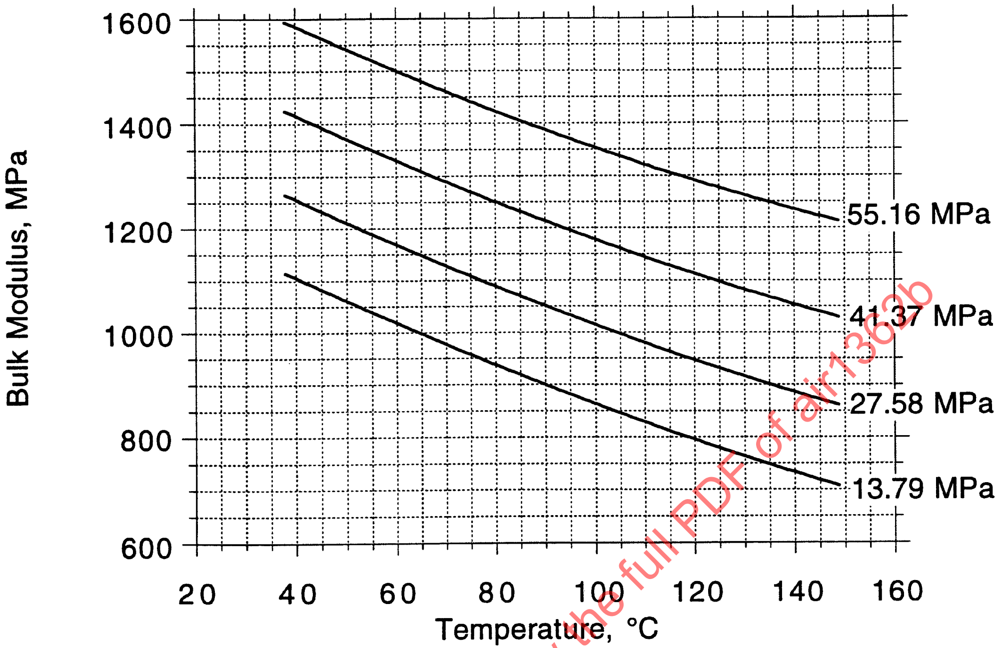

FIGURE 18A - Isothermal Secant Bulk Modulus of MIL-PRF-87257

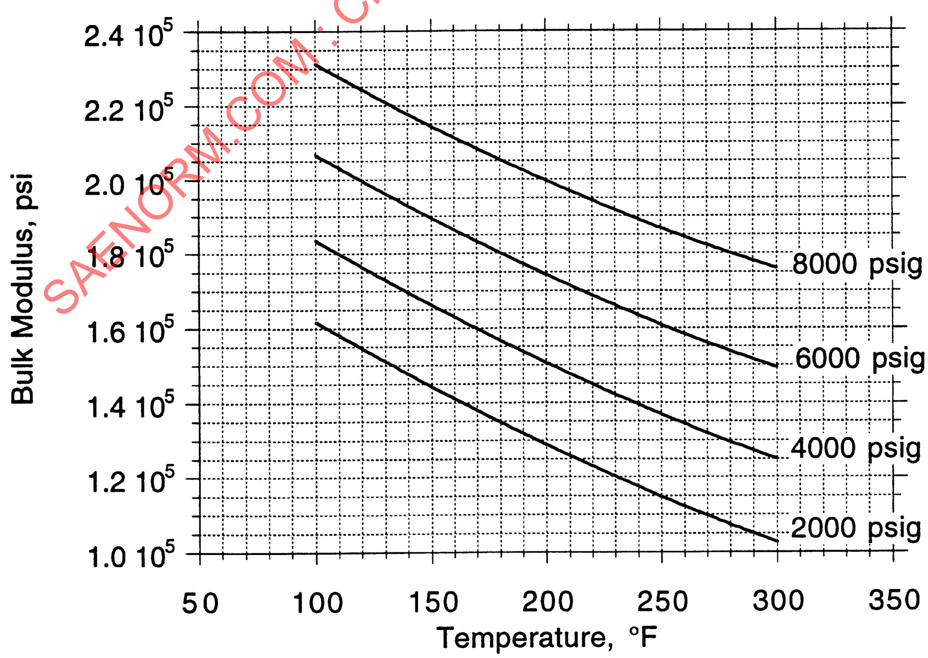

FIGURE 18B - Isothermal Secant Bulk Modulus of MIL-PRF-87257

SAENORM.COM : Click to view the full PDF of air1362b

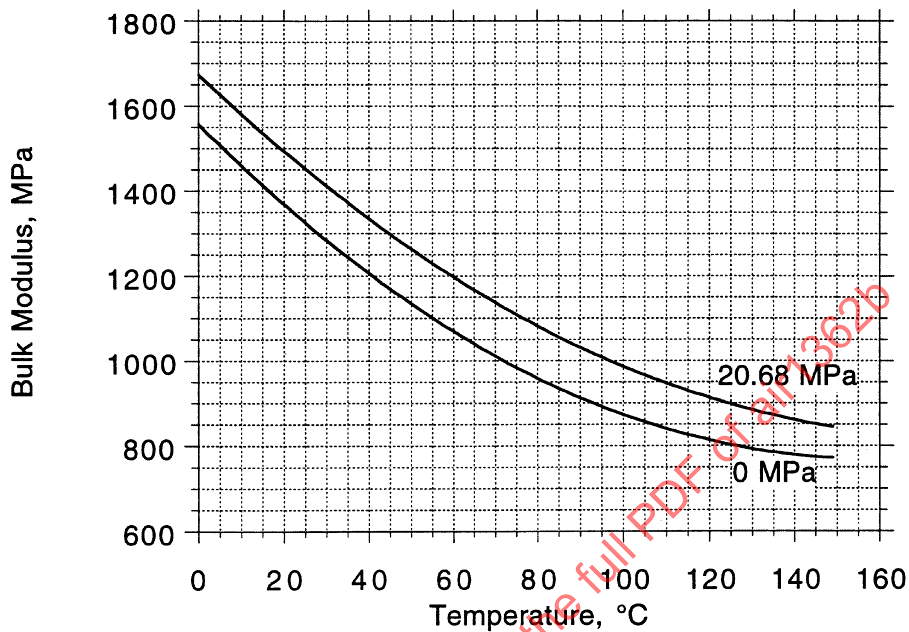

FIGURE 19A - Isothermal Secant Bulk Modulus of AS1241, Type IV, Class 1

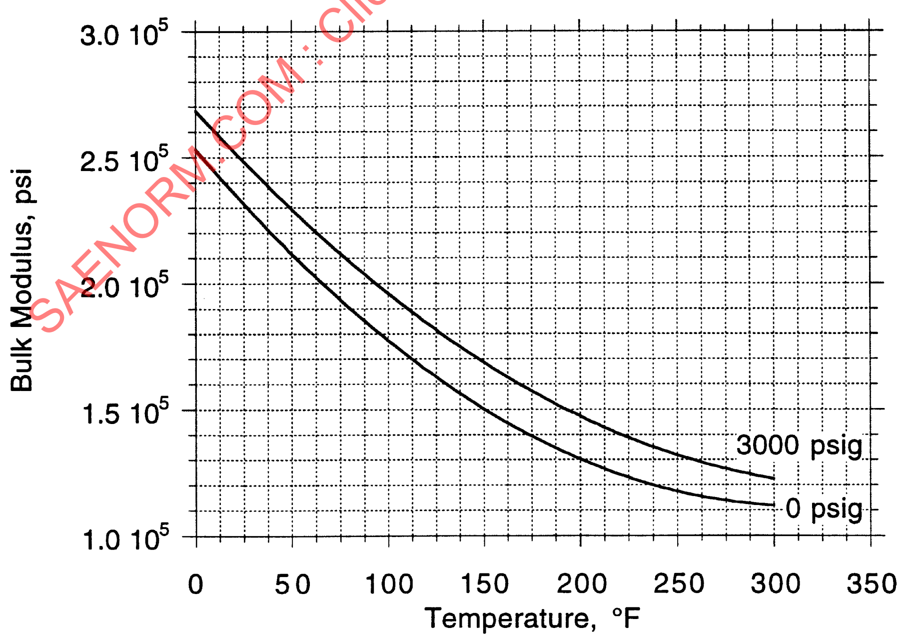

FIGURE 19B - Isothermal Secant Bulk Modulus of AS1241, Type IV, Class 1

SAENORM.COM : Click to view the full PDF of air1362b

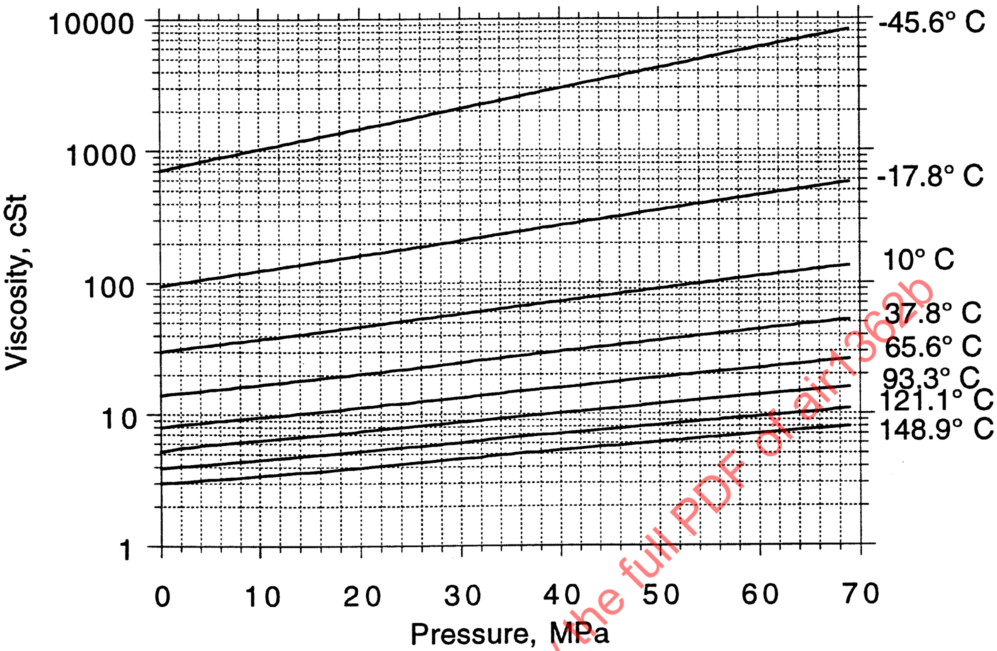

FIGURE 20A - Kinematic Viscosity of MIL-H-5606

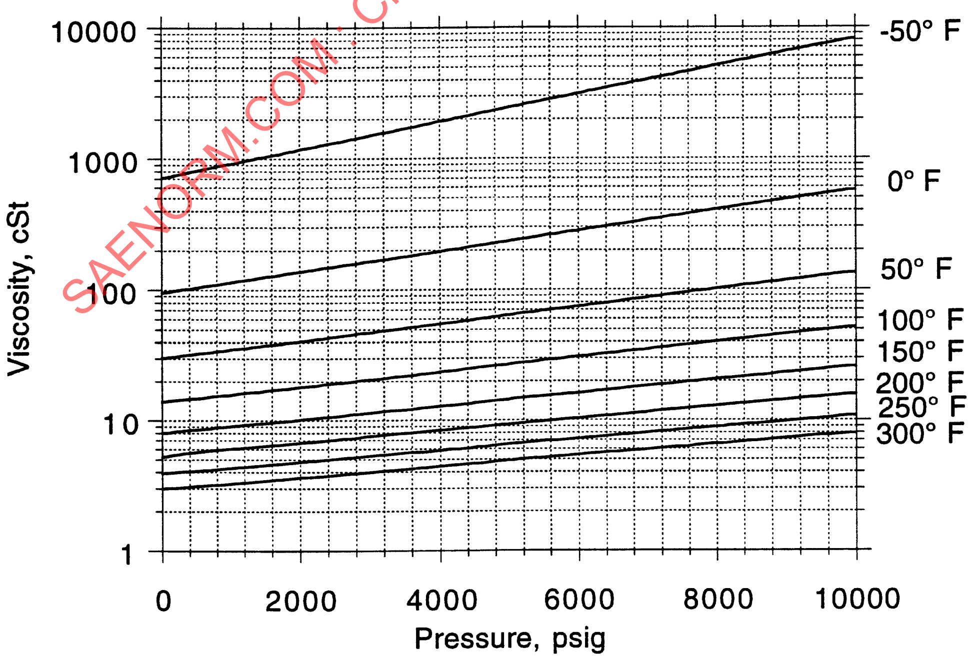

FIGURE 20B - Kinematic Viscosity of MIL-H-5606

SAENORM.COM : Click to view the full PDF of air1362b

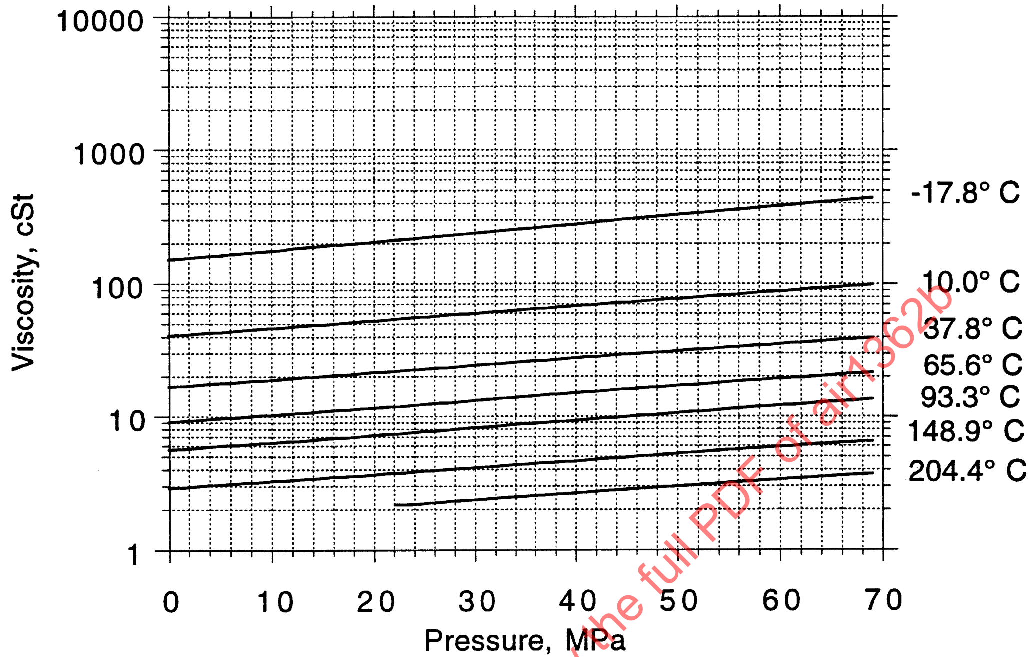

FIGURE 21A - Kinematic Viscosity of MIL-H-8446

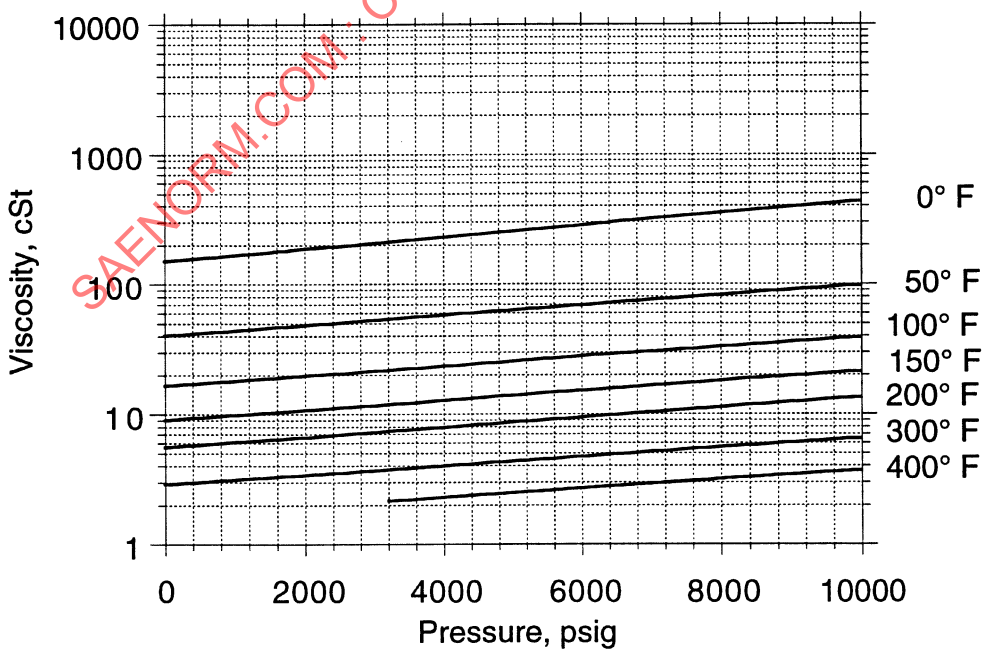

FIGURE 21B - Kinematic Viscosity of MIL-H-8446

SAENORM.COM : Click to view the full PDF of air1362b

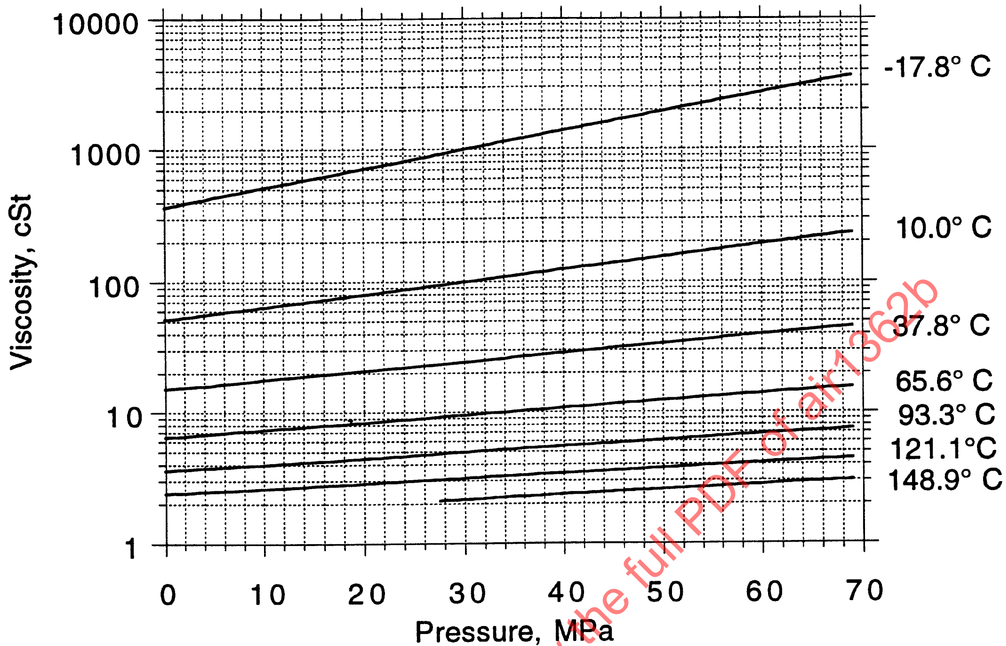

FIGURE 22A - Kinematic Viscosity of MIL-PRF-27601

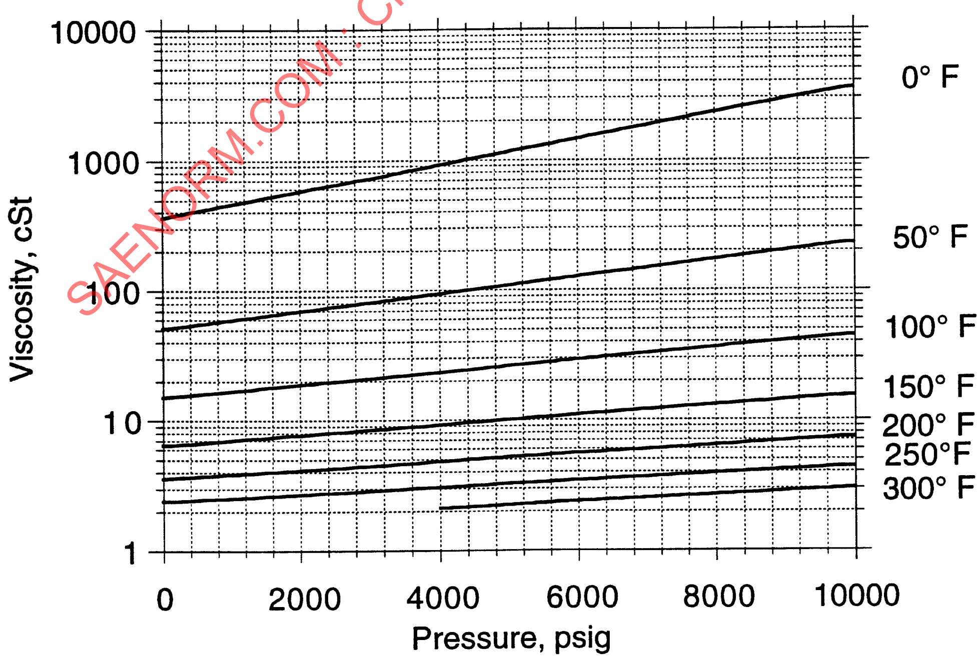

FIGURE 22B - Kinematic Viscosity of MIL-PRF-27601

SAENORM.COM : Click to view the full PDF of air1362b

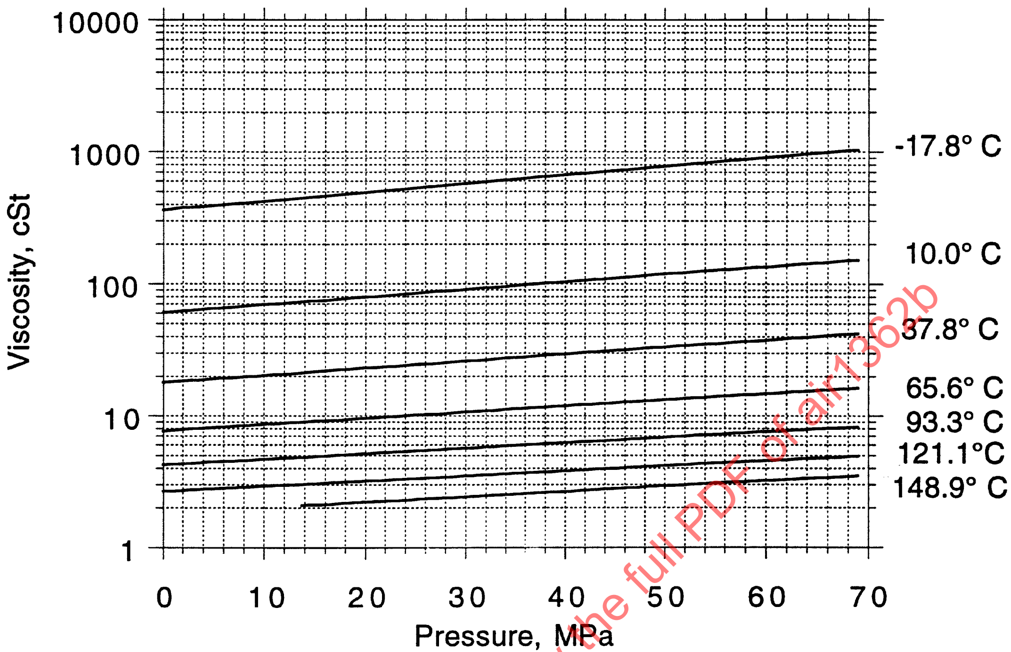

FIGURE 23A - Kinematic Viscosity of MIL-PRF-83282

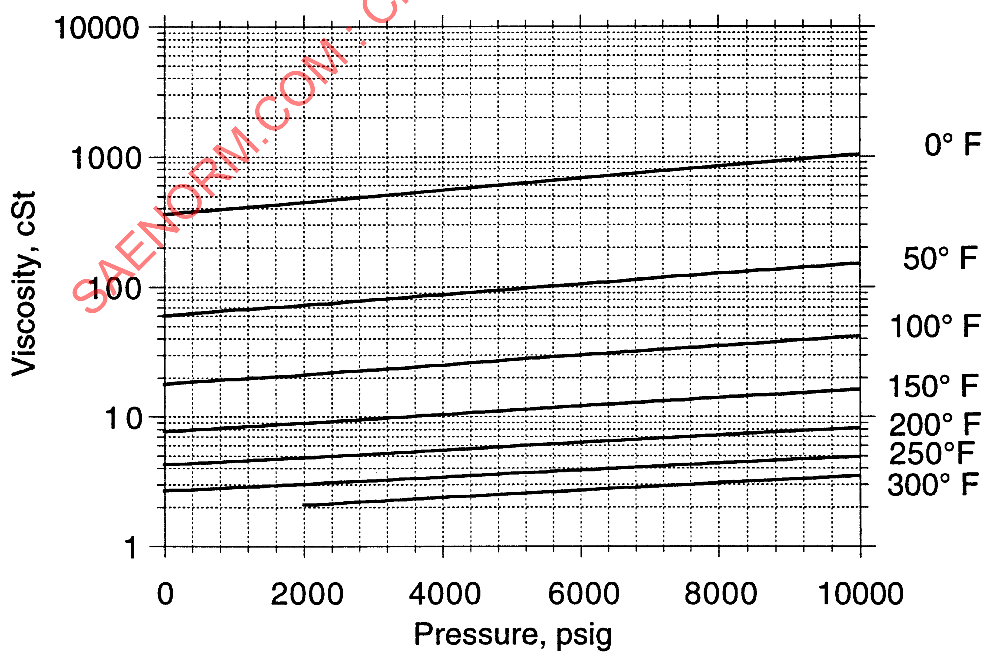

FIGURE 23B - Kinematic Viscosity of MIL-PRF-83282

SAENORM.COM : Click to view the full PDF of air1362b

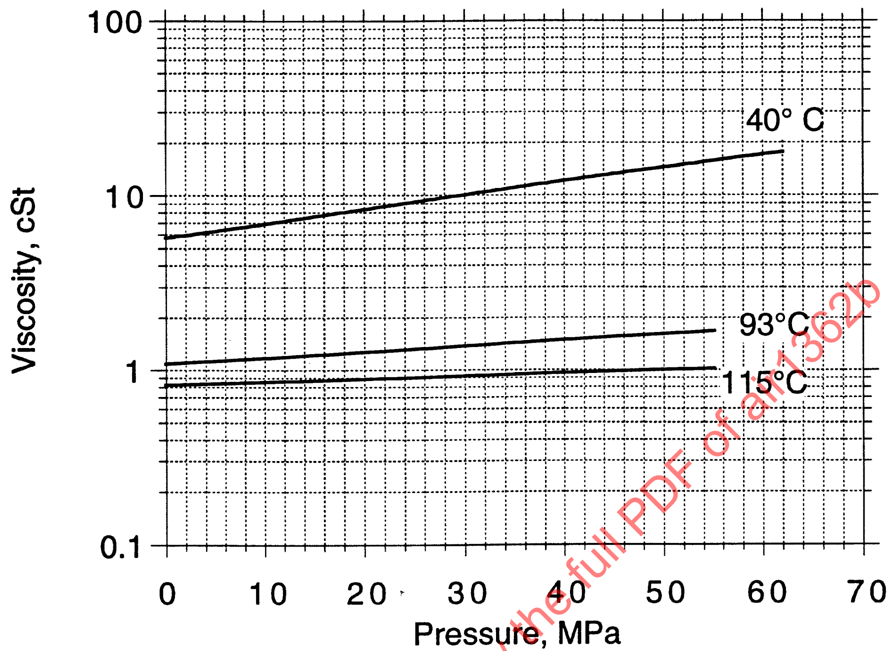

FIGURE 24A - Kinematic Viscosity of MIL-H-53119

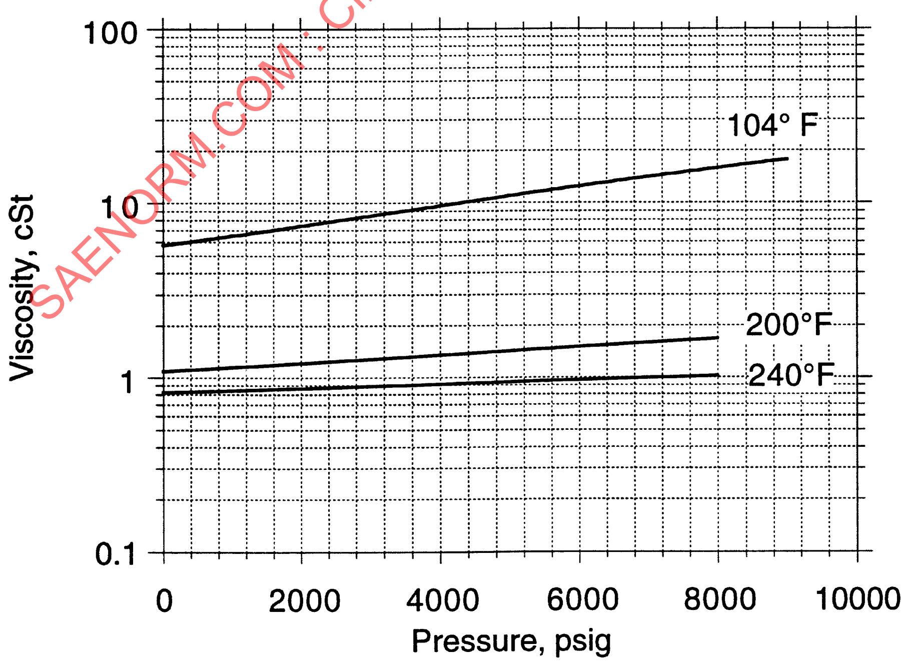

FIGURE 24B - Kinematic Viscosity of MIL-H-53119

SAENORM.COM : Click to view the full PDF of air1362b

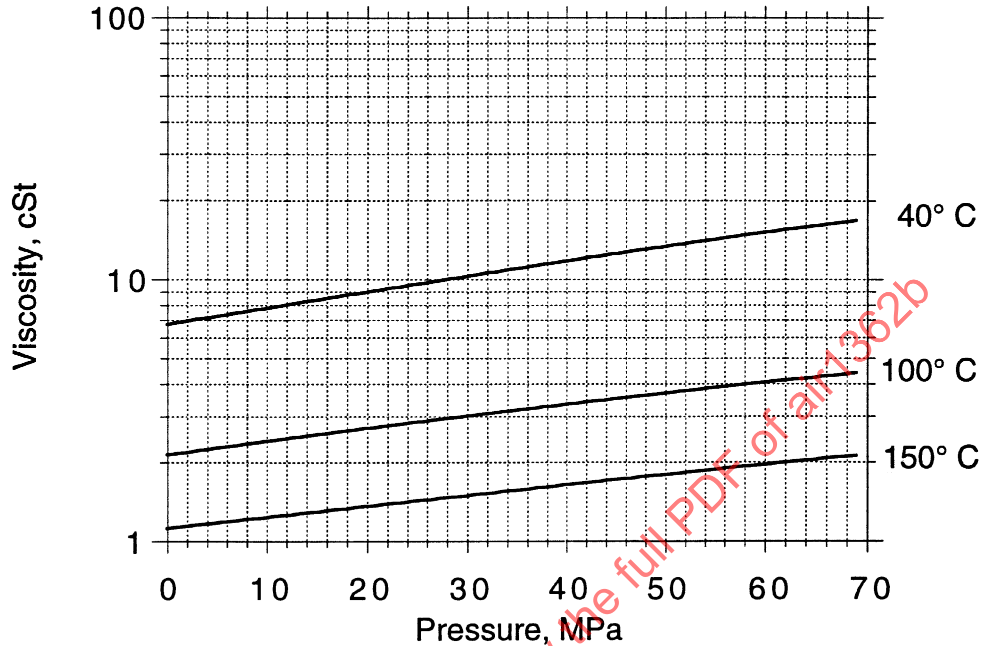

FIGURE 25A - Kinematic Viscosity of MIL-PRF-87257

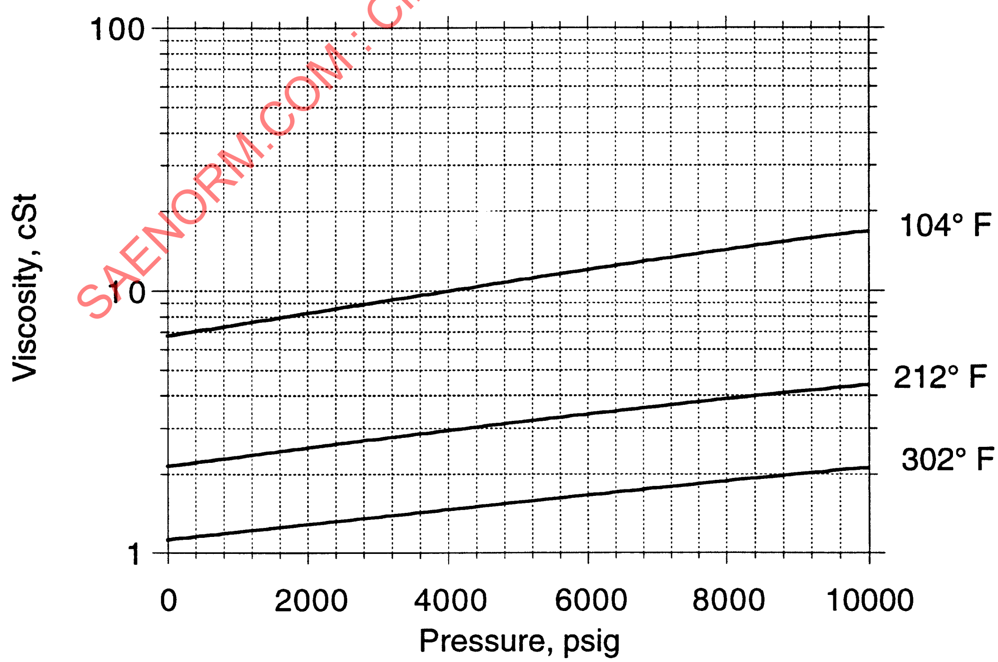

FIGURE 25B - Kinematic Viscosity of MIL-PRF-87257

SAENORM.COM : Click to view the full PDF of air1362b

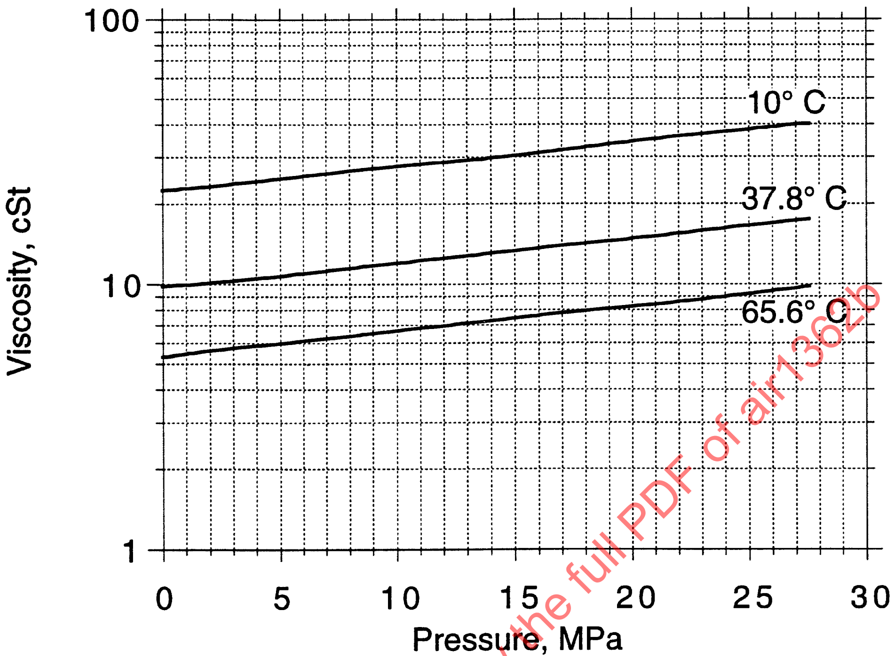

FIGURE 26A - Kinematic Viscosity of AS1241, Type IV, Class 1

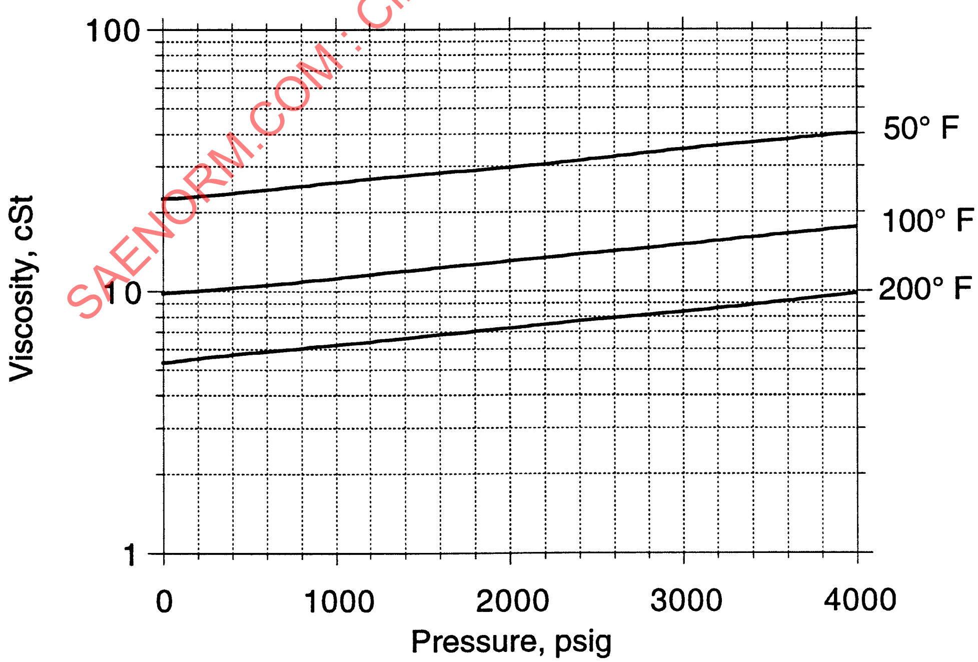

FIGURE 26B - Kinematic Viscosity of AS1241, Type IV, Class 1

SAENORM.COM : Click to view the full PDF of air1362b

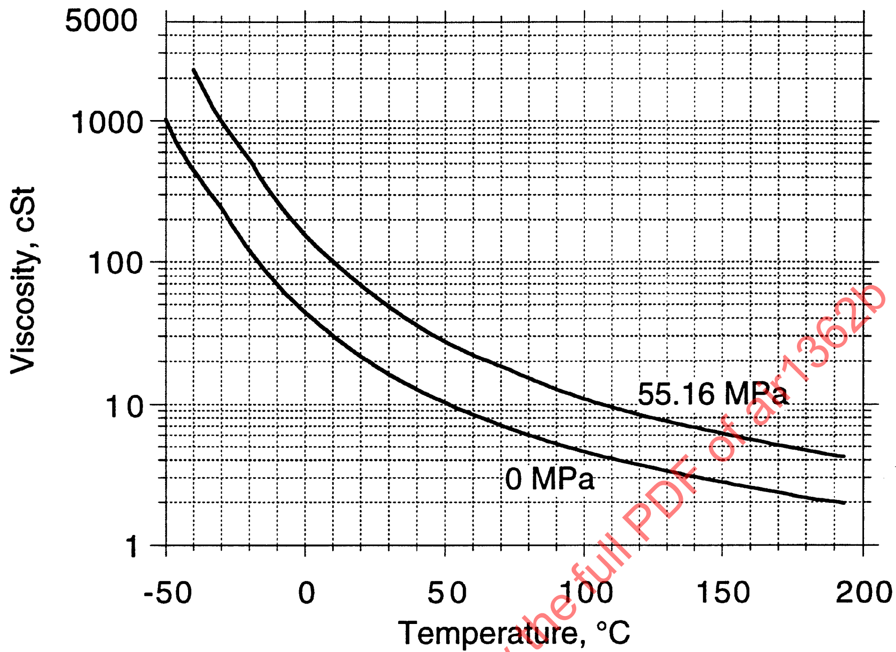

FIGURE 27A - Kinematic Viscosity of MIL-H-5606

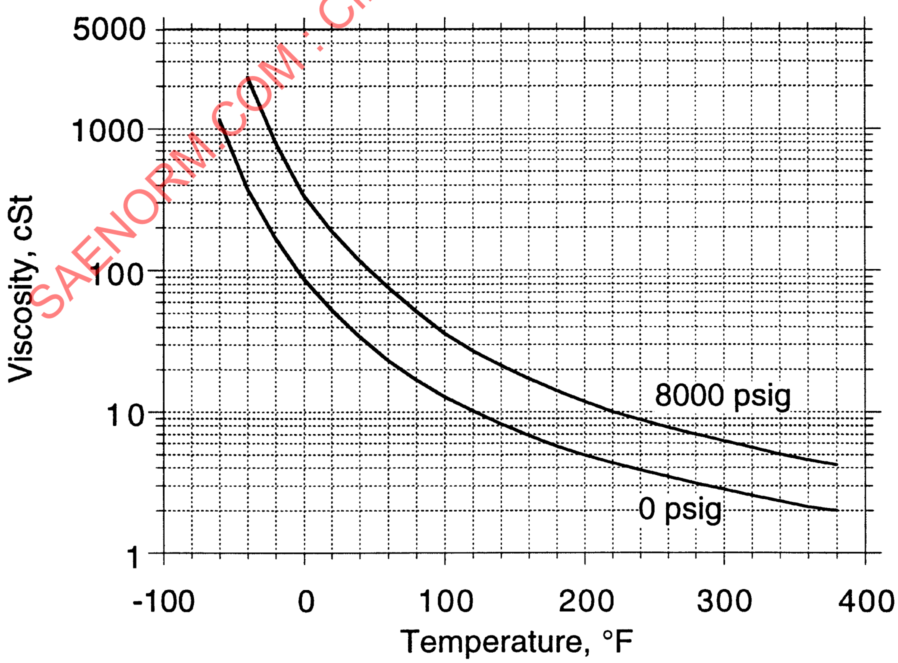

FIGURE 27B - Kinematic Viscosity of MIL-H-5606

SAENORM.COM : Click to view the full PDF of air1362b

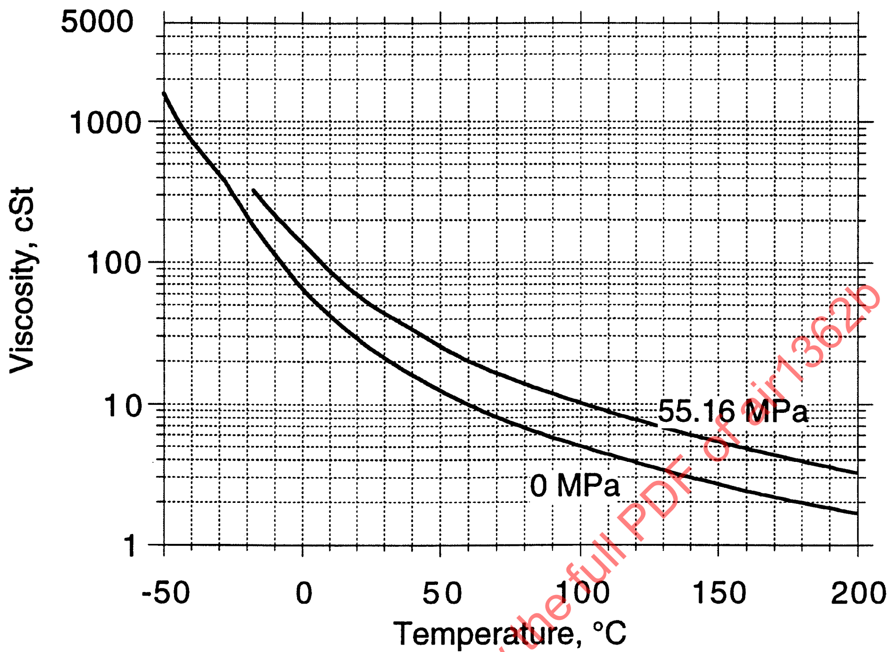

FIGURE 28A - Kinematic Viscosity of MIL-H-8446

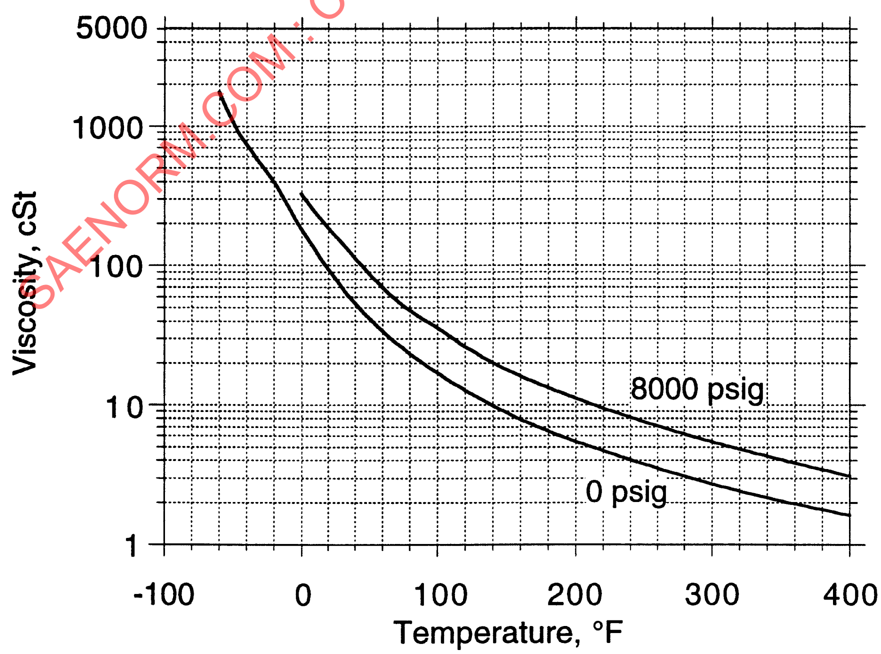

FIGURE 28B - Kinematic Viscosity of MIL-H-8446

SAENORM.COM : Click to view the full PDF of air1362b

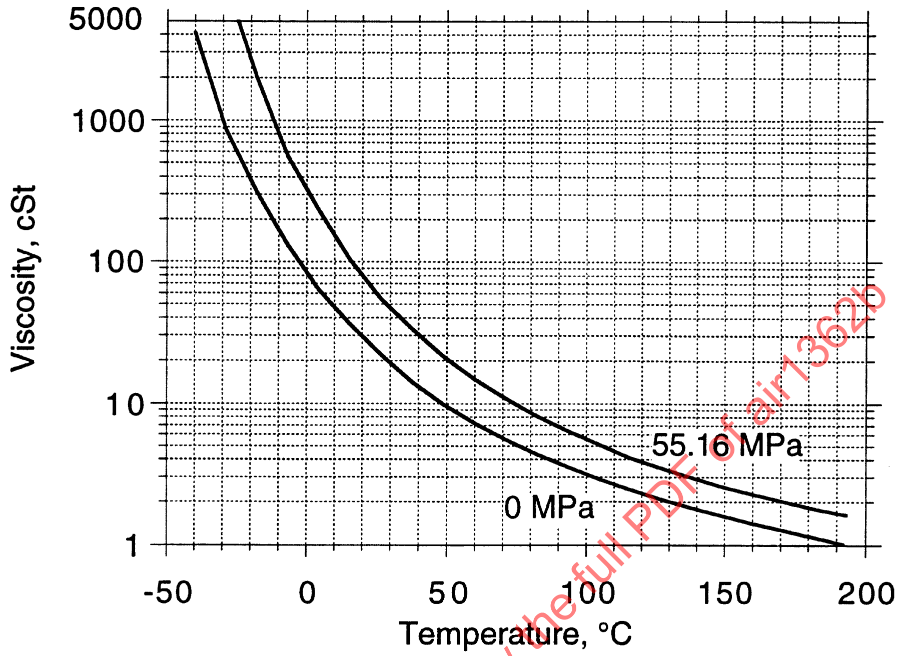

FIGURE 29A - Kinematic Viscosity of MIL-PRF-27601

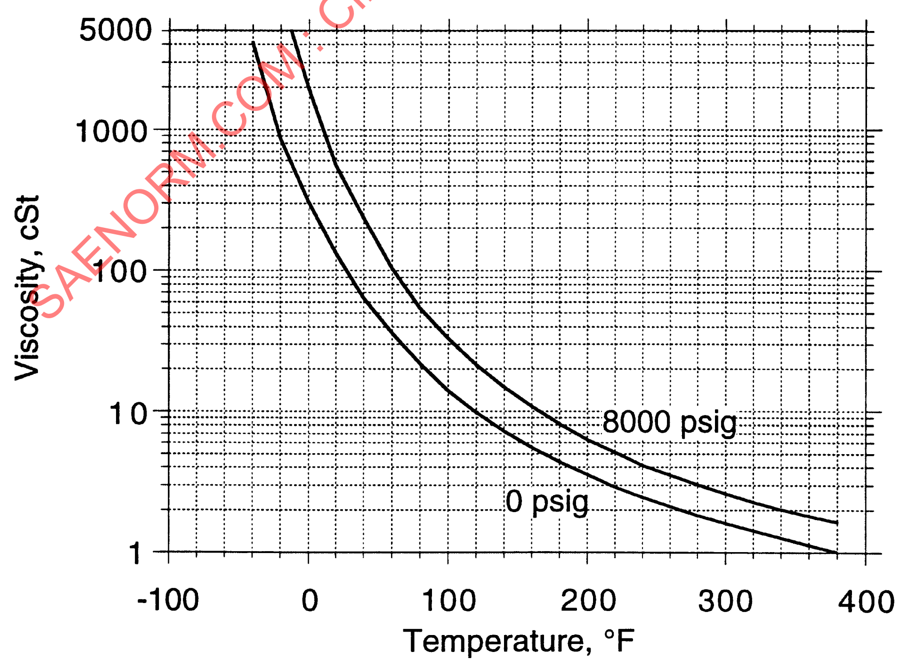

FIGURE 29B - Kinematic Viscosity of MIL-PRF-27601

SAENORM.COM : Click to view the full PDF of air1362b

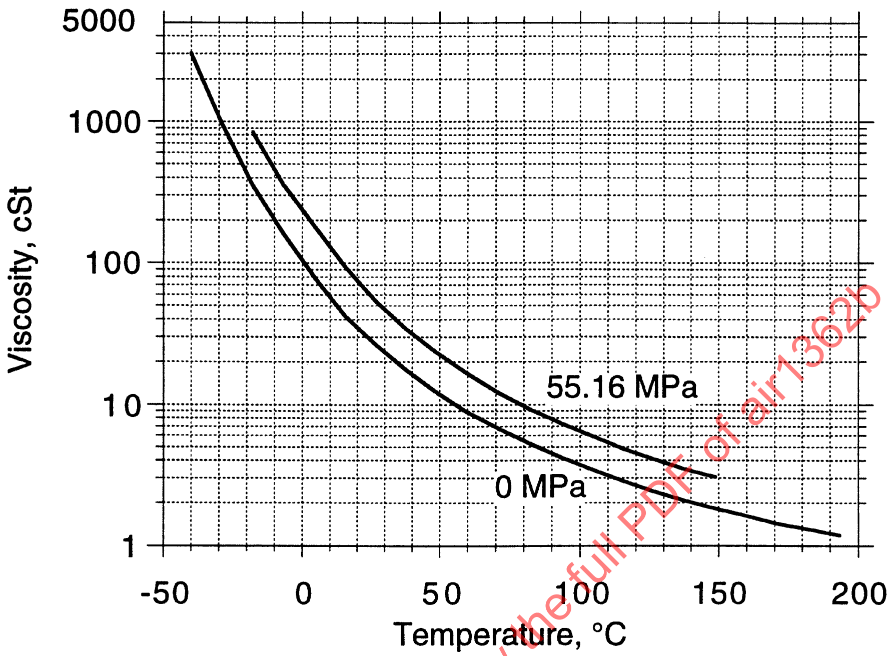

FIGURE 30A - Kinematic Viscosity of MIL-PRF-83282

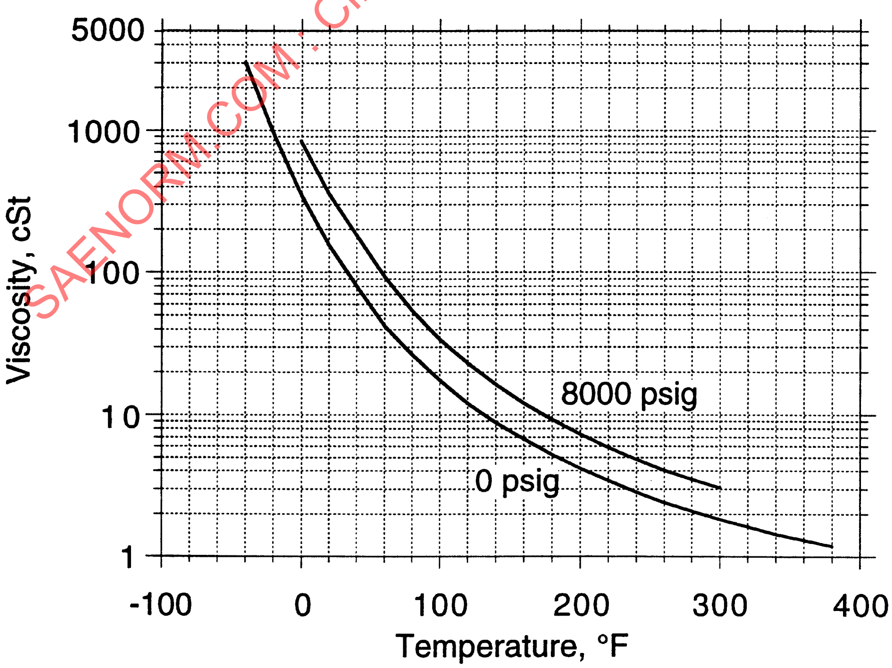

FIGURE 30B - Kinematic Viscosity of MIL-PRF-83282

SAENORM.COM : Click to view the full PDF of air1362b

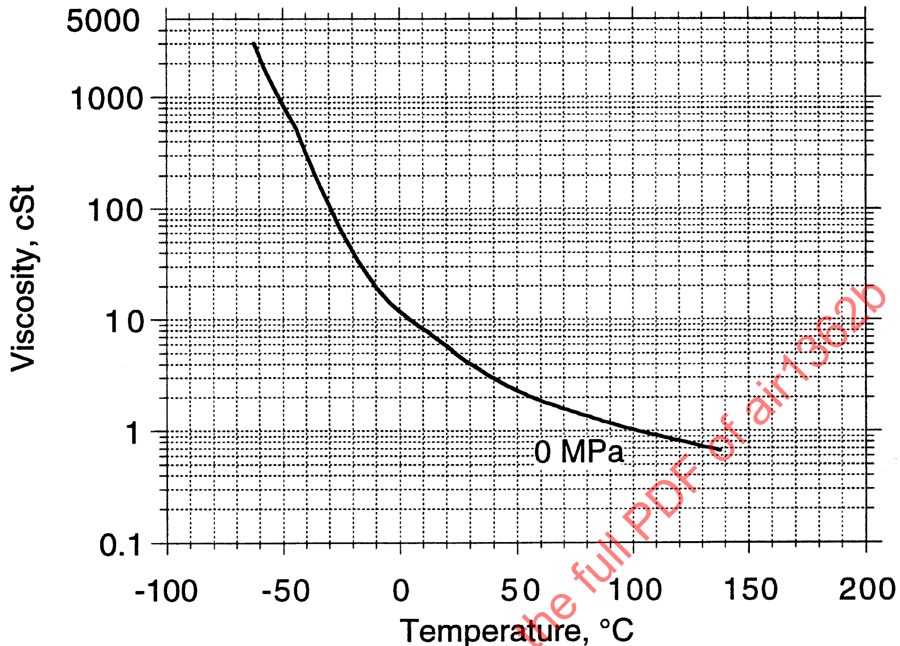

FIGURE 31A - Kinematic Viscosity of MIL-H-53119

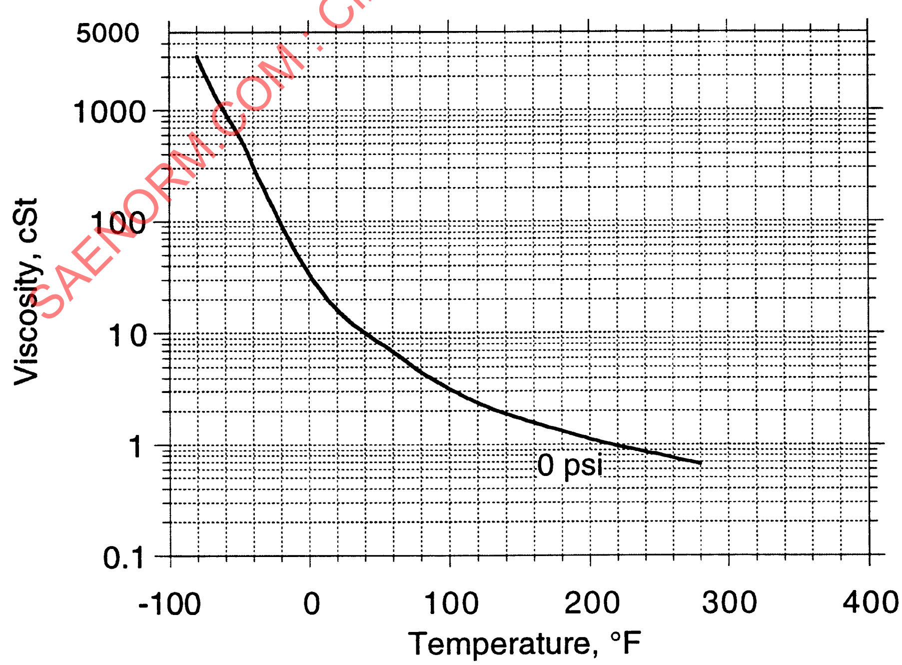

FIGURE 31B - Kinematic Viscosity of MIL-H-53119

SAENORM.COM : Click to view the full PDF of air1362b

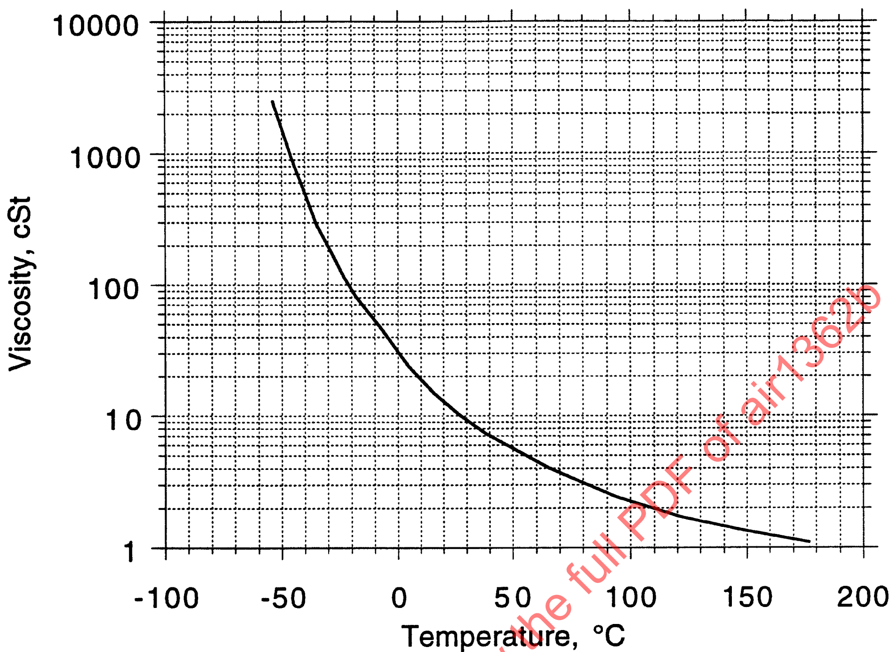

FIGURE 32A - Kinematic Viscosity of MIL-PRF-87257 at Atmospheric Pressure

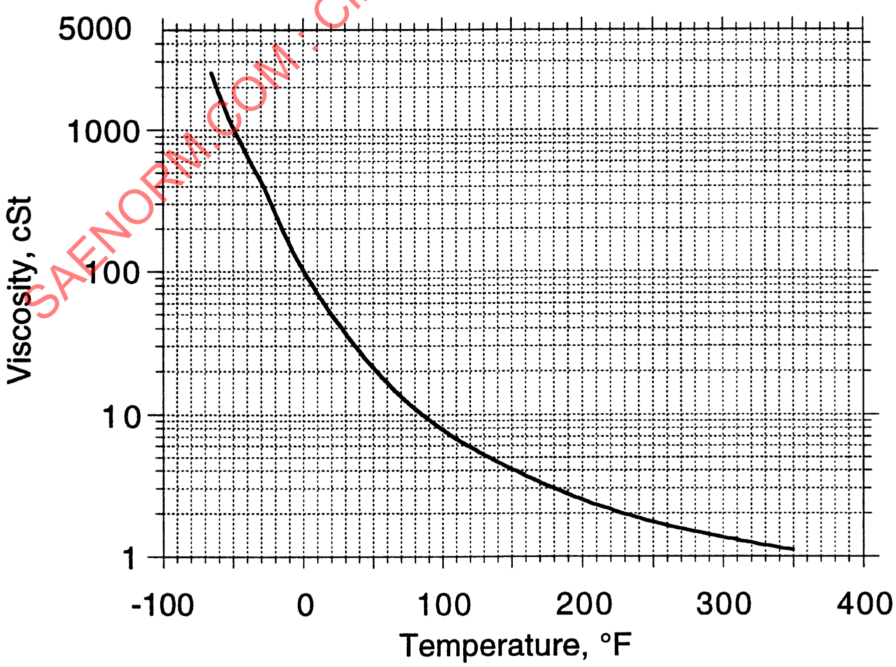

FIGURE 32B - Kinematic Viscosity of MIL-PRF-87257 at Atmospheric Pressure

SAENORM.COM : Click to view the full PDF of air1362b