Evaluation of 4 mm DSR results using a Peltier Cooling System

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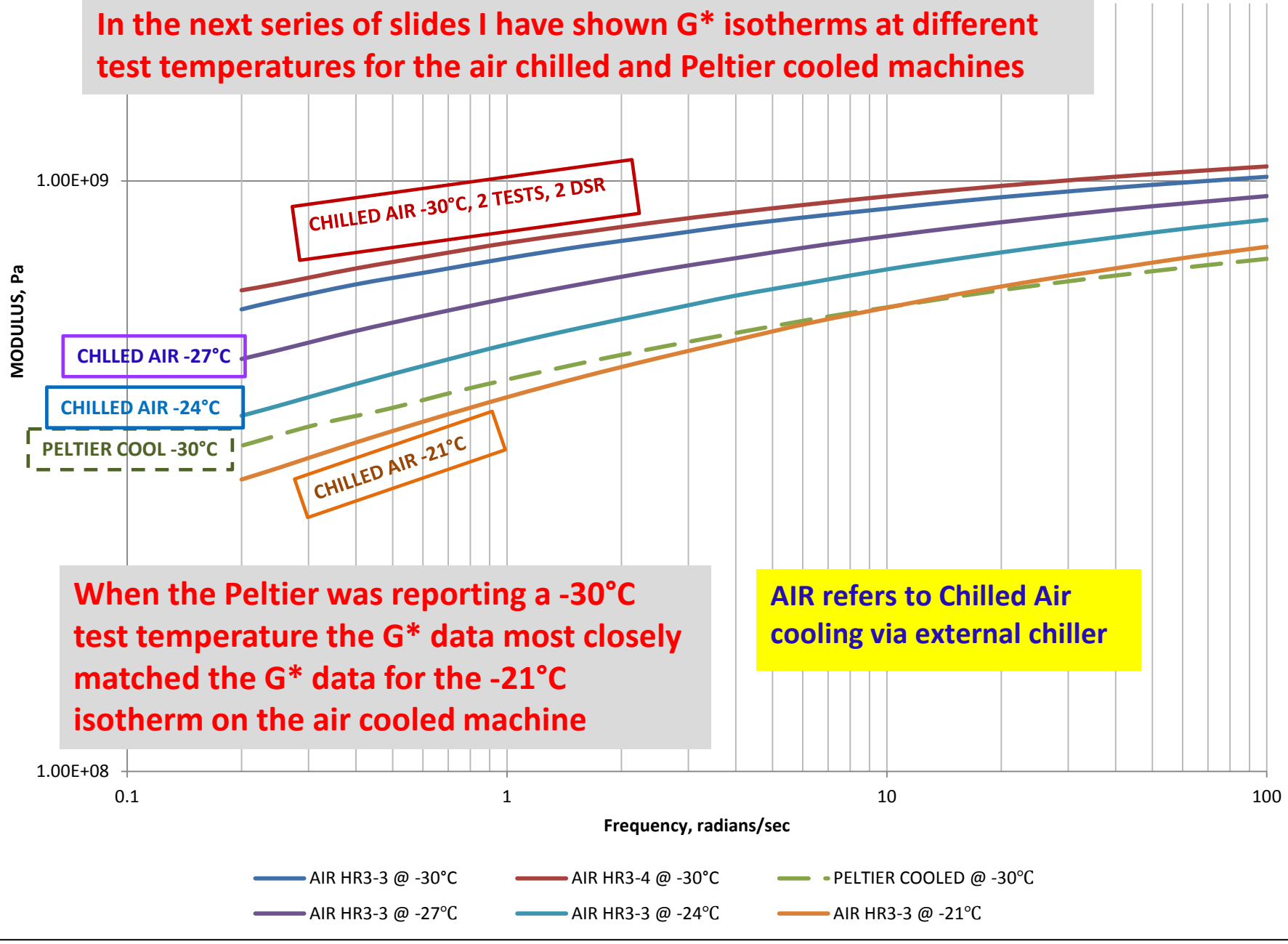
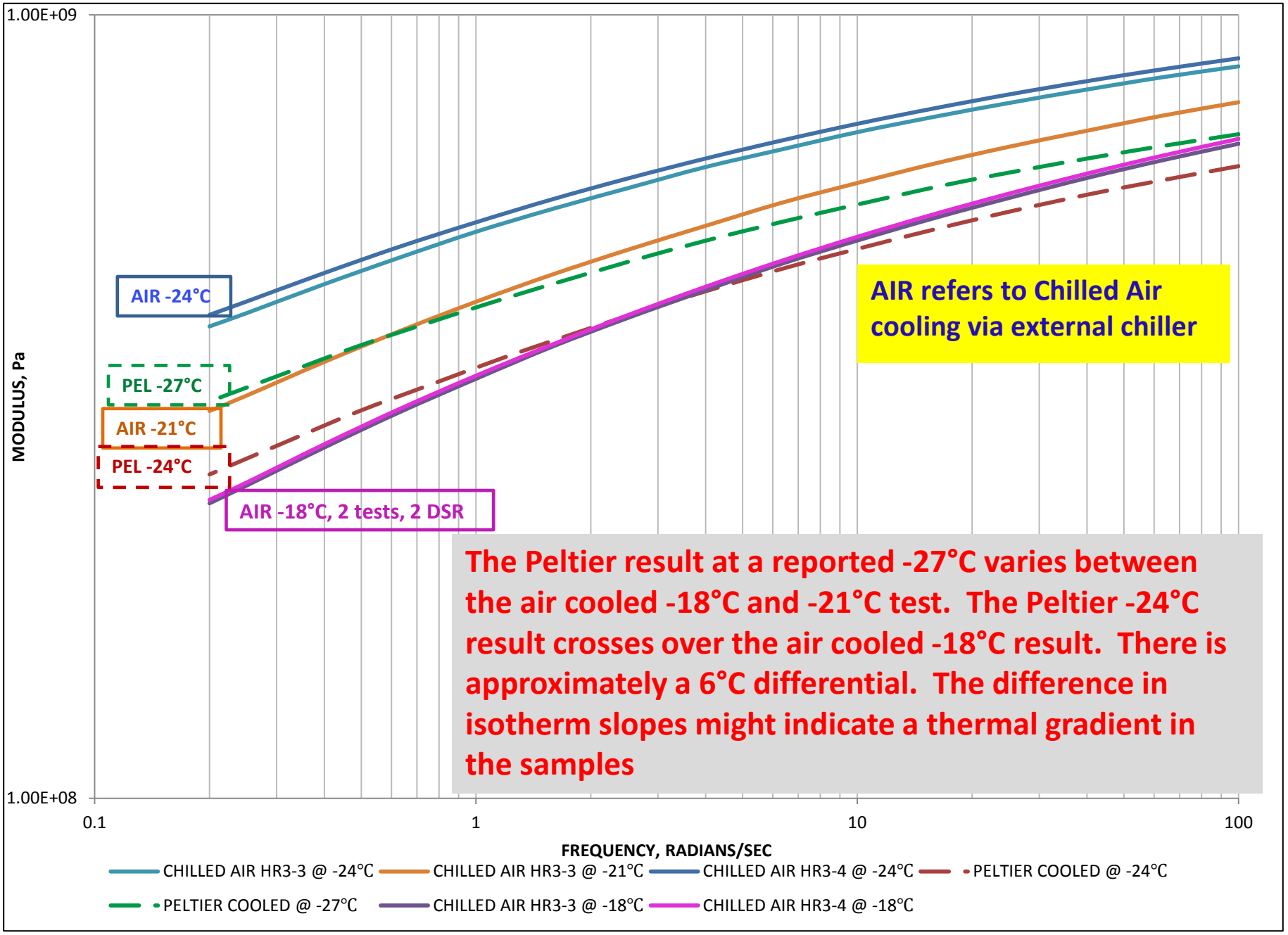
ISOTHERMAL DATA FROM MAY 2017 ETG

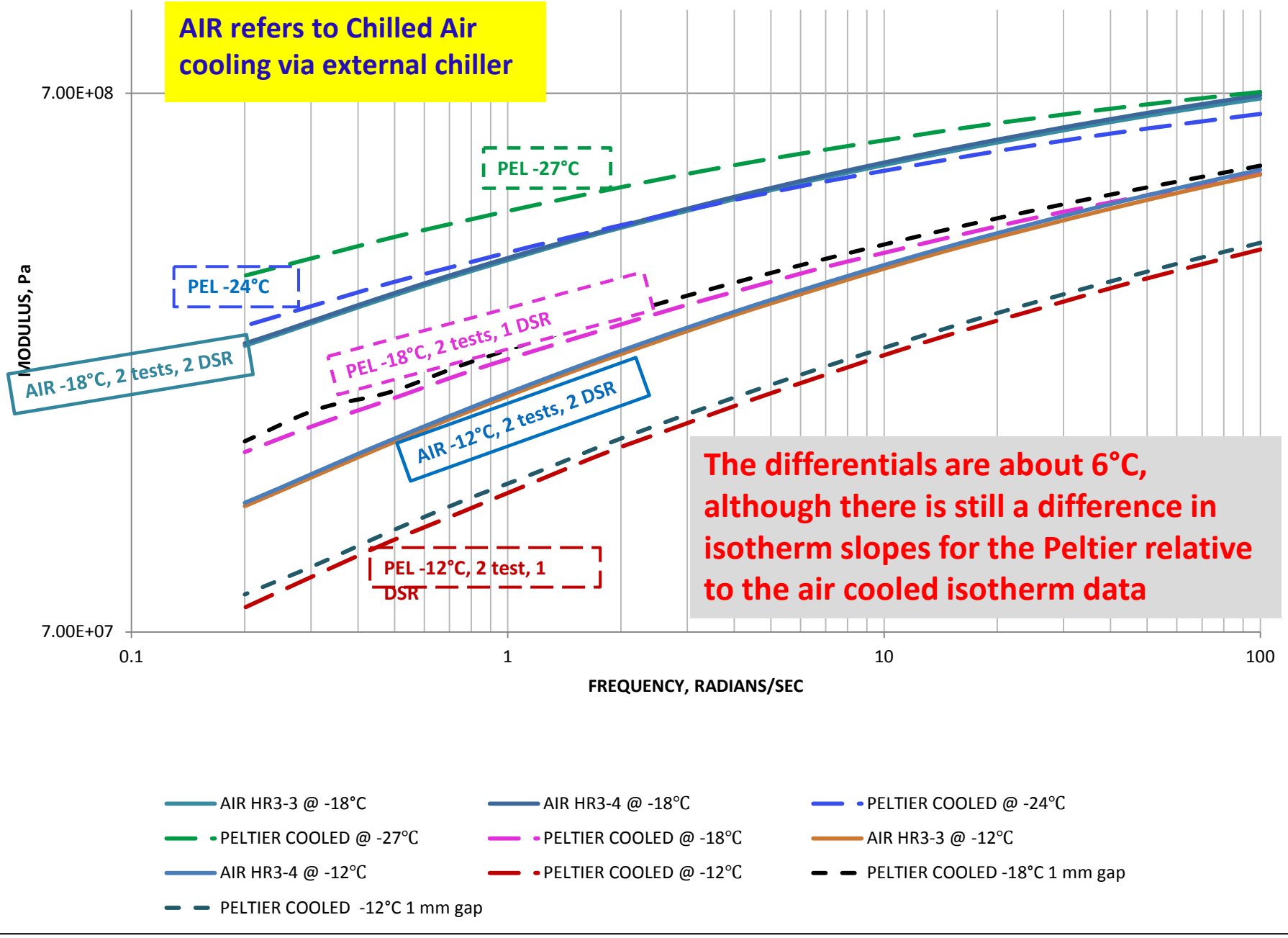
In the next series of slides I have shown G* isotherms at different test temperatures for the air chilled and Peltier cooled machines

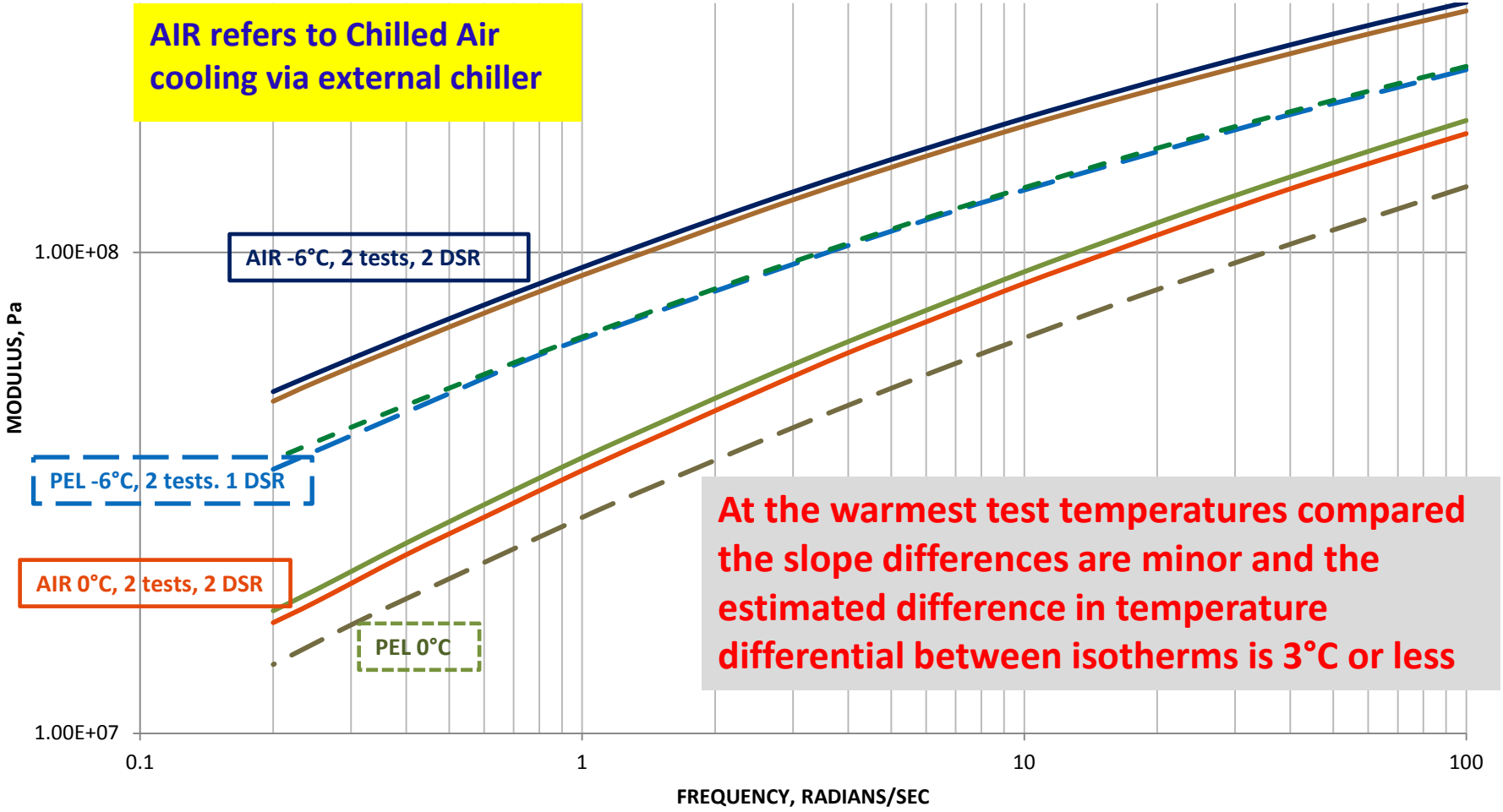


When the Peltier was reporting a -30°C test temperature the G* data most closely matched the G* data for the -21°C isotherm on the air cooled machine

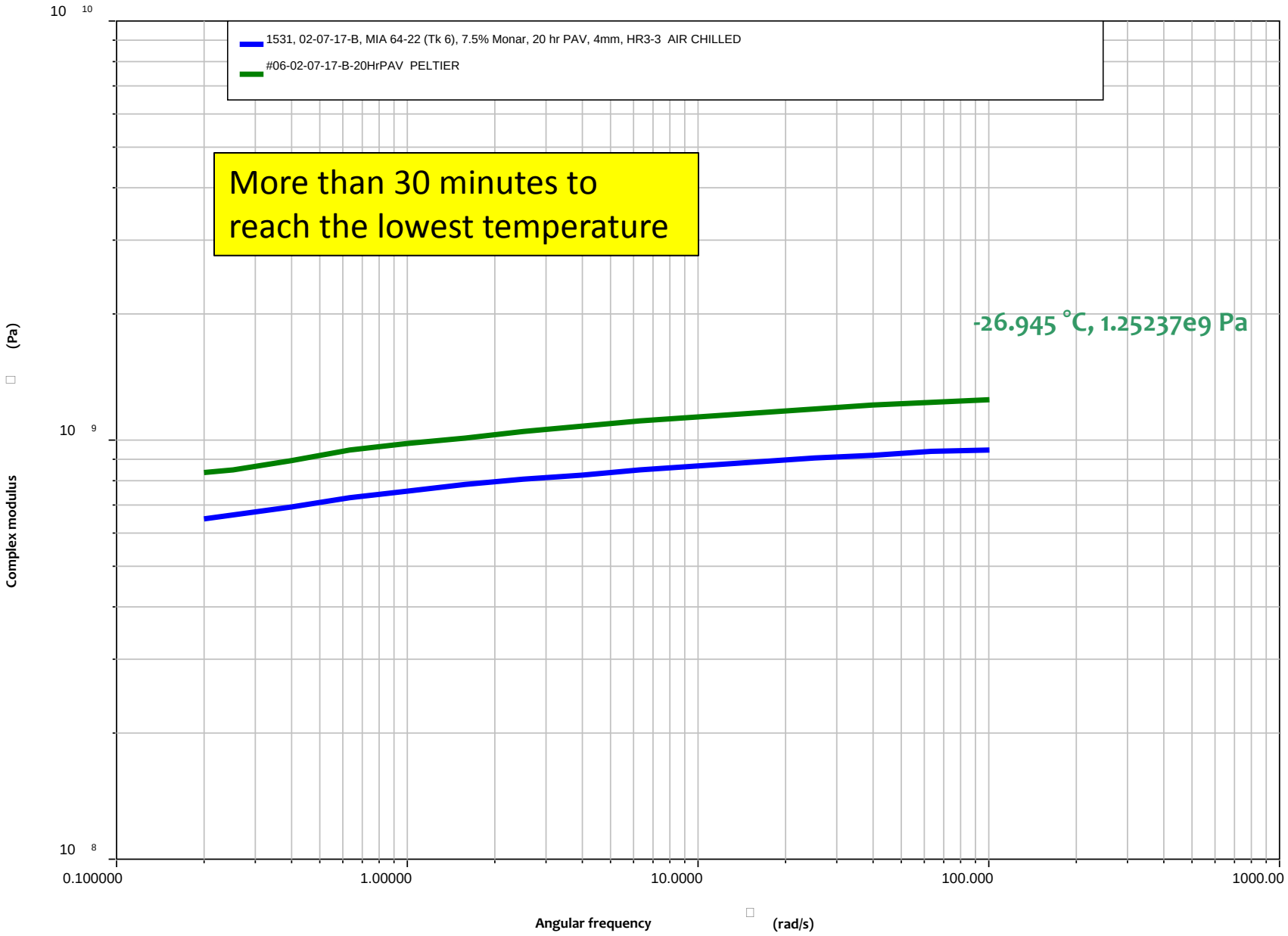
AIR refers to Chilled Air cooling via external chiller


1.00E+09
1.00E+08
MODULUS, Pa
0.1
1
10
100
FREQUENCY, RADIANS/SEC
AIR -24°C
PEL -27°C
AIR -21°C
PEL -24°C
AIR -18°C, 2 tests, 2 DSR
AIR refers to Chilled Air cooling via external chiller
The Peltier result at a reported -27°C varies between the air cooled -18°C and -21°C test. The Peltier -24°C result crosses over the air cooled -18°C result. There is approximately a 6°C differential. The difference in isotherm slopes might indicate a thermal gradient in the samples
CHILLED AIR HR3-3 @ -24°C
CHILLED AIR HR3-3 @ -21°C
CHILLED AIR HR3-4 @ -24°C
PELTIER COOLED @ -24°C
PELTIER COOLED @ -27°C
CHILLED AIR HR3-3 @ -18°C
CHILLED AIR HR3-4 @ -18°C

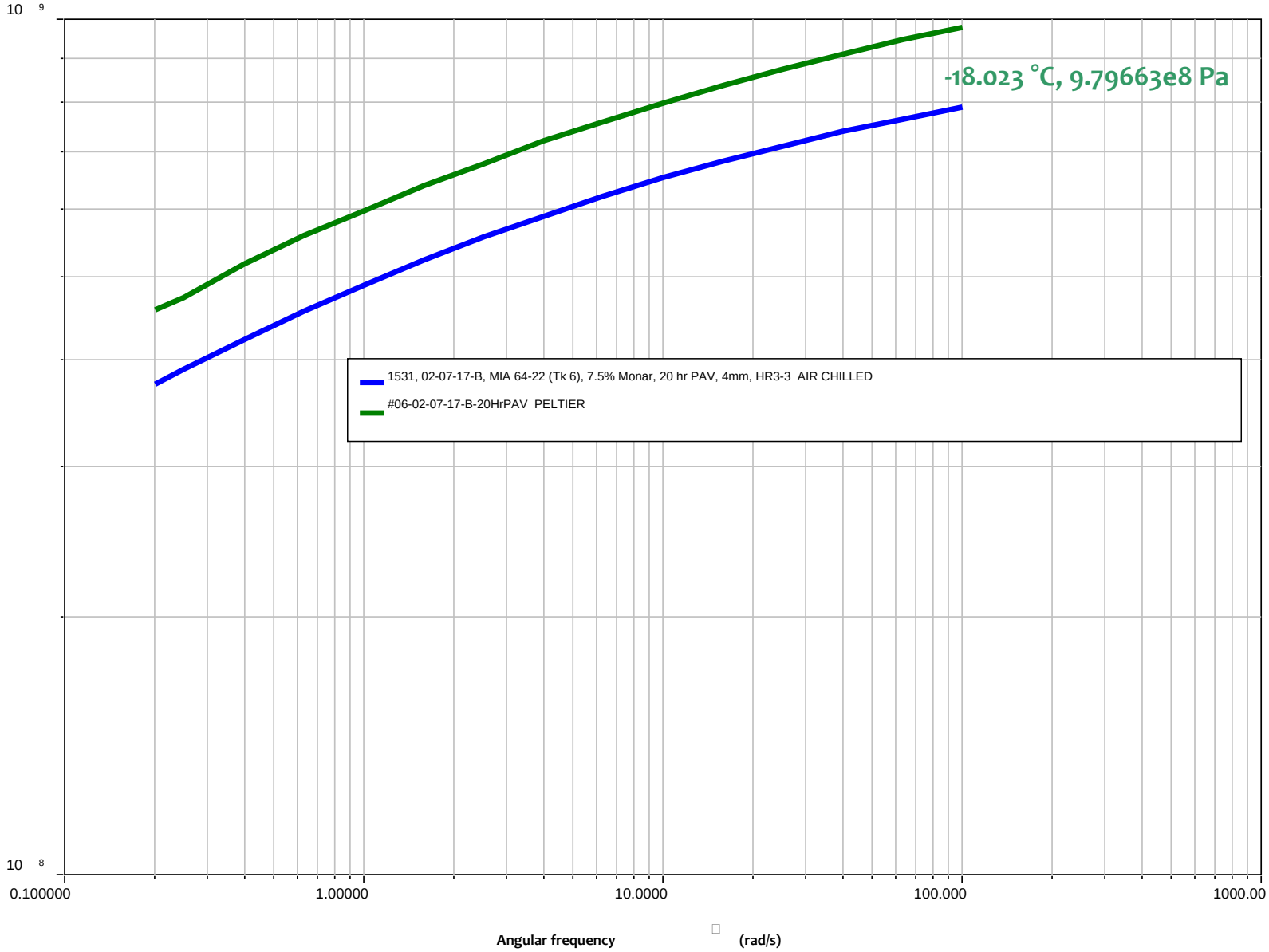

AIR refers to Chilled Air cooling via external chiller
7.00E+08
7.00E+07
MODULUS, Pa
0.1
1
10
100
FREQUENCY, RADIANS/SEC
PEL -27°C
PEL -24°C
PEL -18°C, 2 tests, 1 DSR
AIR -18°C, 2 tests, 2 DSR
AIR -12°C, 2 tests, 2 DSR
PEL -12°C, 2 test, 1 DSR
The differentials are about 6°C, although there is still a difference in isotherm slopes for the Peltier relative to the air cooled isotherm data
AIR HR3-3 @ -18°C
AIR HR3-4 @ -18°C
PELTIER COOLED @ -24°C
PELTIER COOLED @ -27°C
PELTIER COOLED @ -18°C
AIR HR3-3 @ -12°C
AIR HR3-4 @ -12°C
PELTIER COOLED @ -12°C
PELTIER COOLED -18°C 1 mm gap
PELTIER COOLED -12°C 1 mm gap


AIR refers to Chilled Air cooling via external chiller
AIR -6°C, 2 tests, 2 DSR
PEL -6°C, 2 tests. 1 DSR
AIR 0°C, 2 tests, 2 DSR
PEL 0°C
At the warmest test temperatures compared the slope differences are minor and the estimated difference in temperature differential between isotherms is 3°C or less
1.00E+08
1.00E+07
MODULUS, Pa
0.1
1
10
100
FREQUENCY, RADIANS/SEC
AIR HR3-3 @ -6°C
AIR HR3-4 @ -6°C
PELTIER COOLED @ -6°C
AIR HR3-3 @ 0°C
AIR HR3-4 @ 0°C
PELTIER COOLED @ 0°C
PELTIER COOLED -6°C 1 mm gap

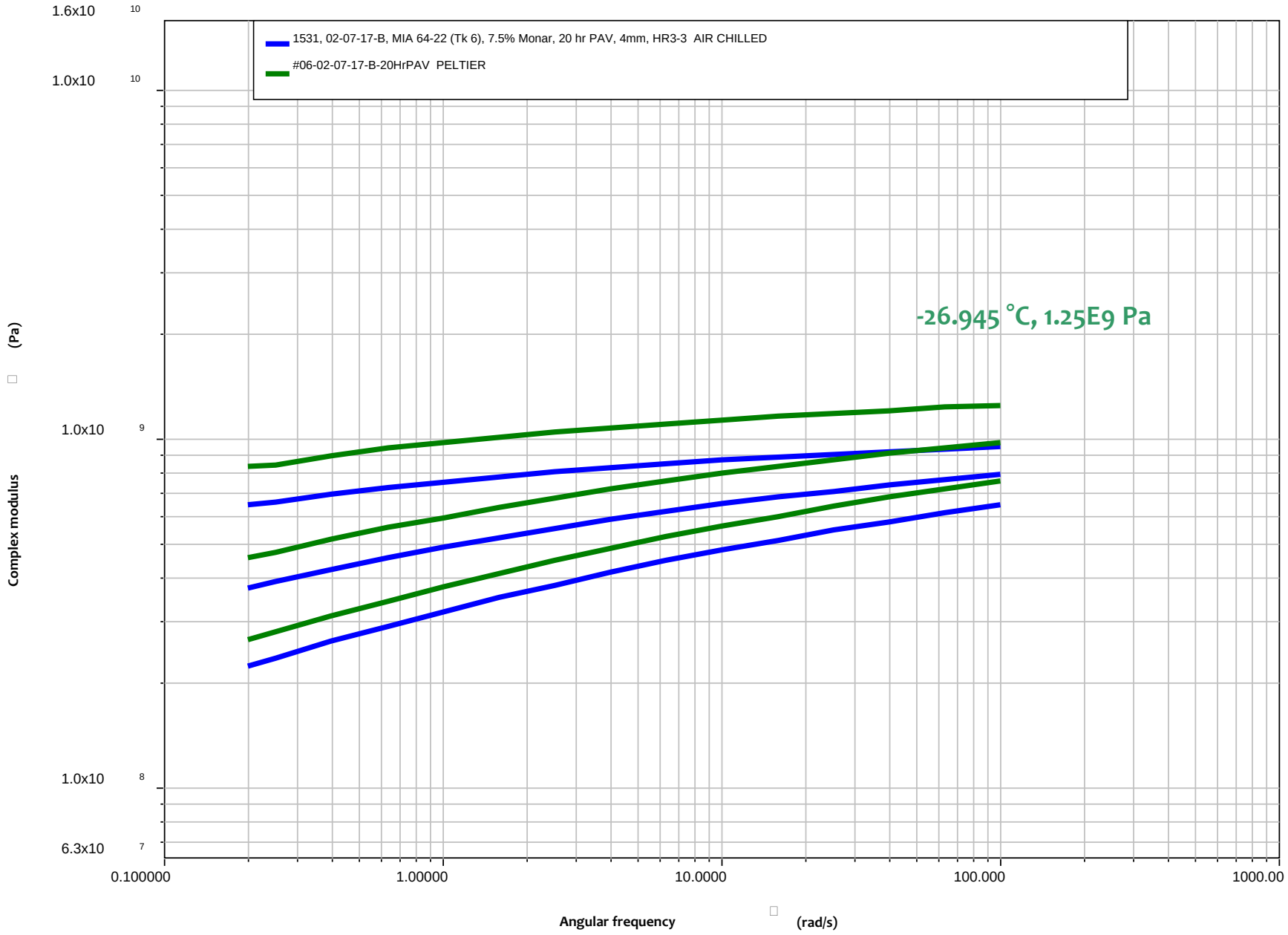
1531, 02-07-17-B, MIA 64-22 (Tk 6), 7.5% Monar, 20 hr PAV, 4mm, HR3-3



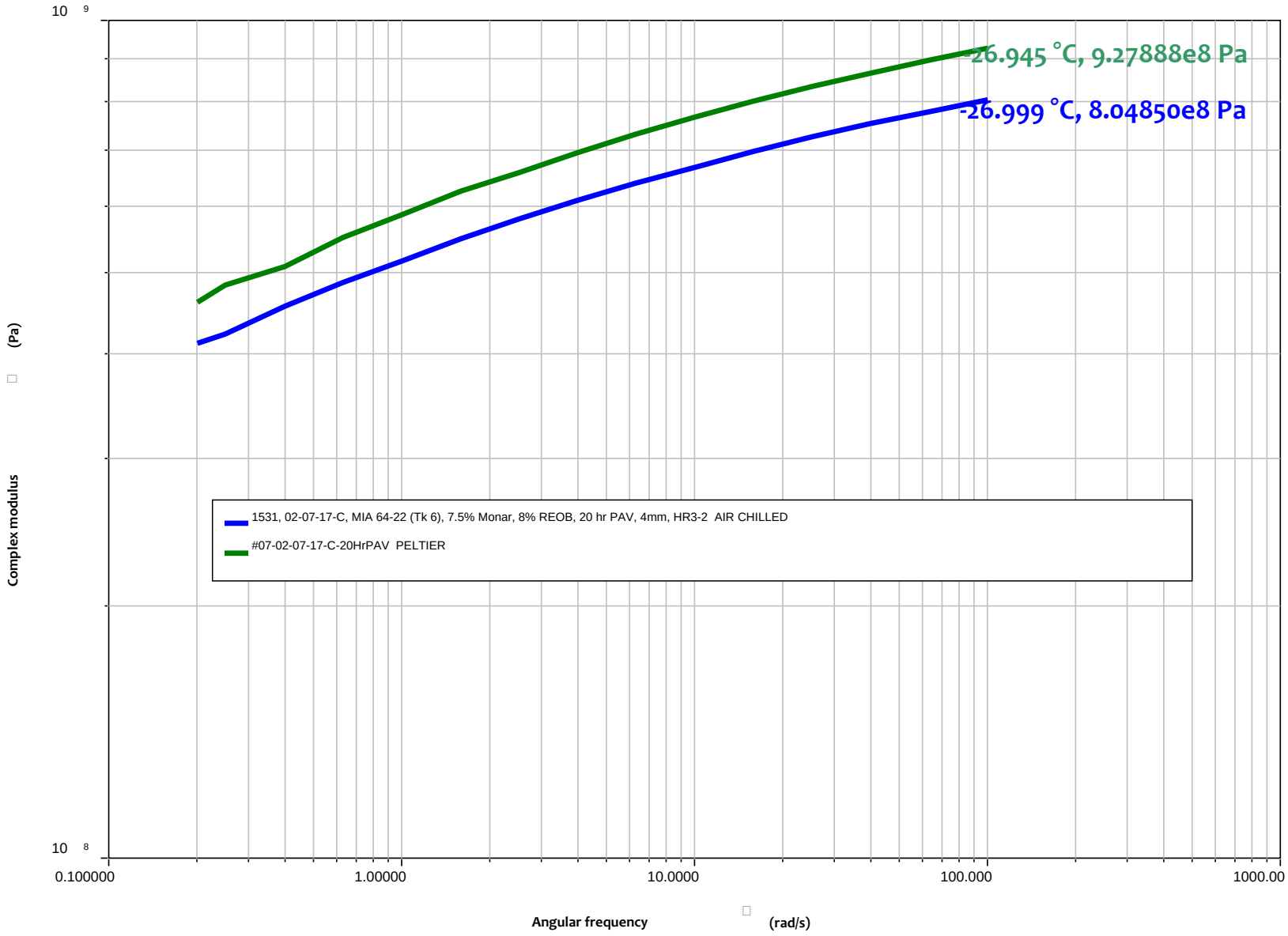
1531, 02-07-17-B, MIA 64-22 (Tk 6), 7.5% Monar, 20 hr PAV, 4mm, HR3-3



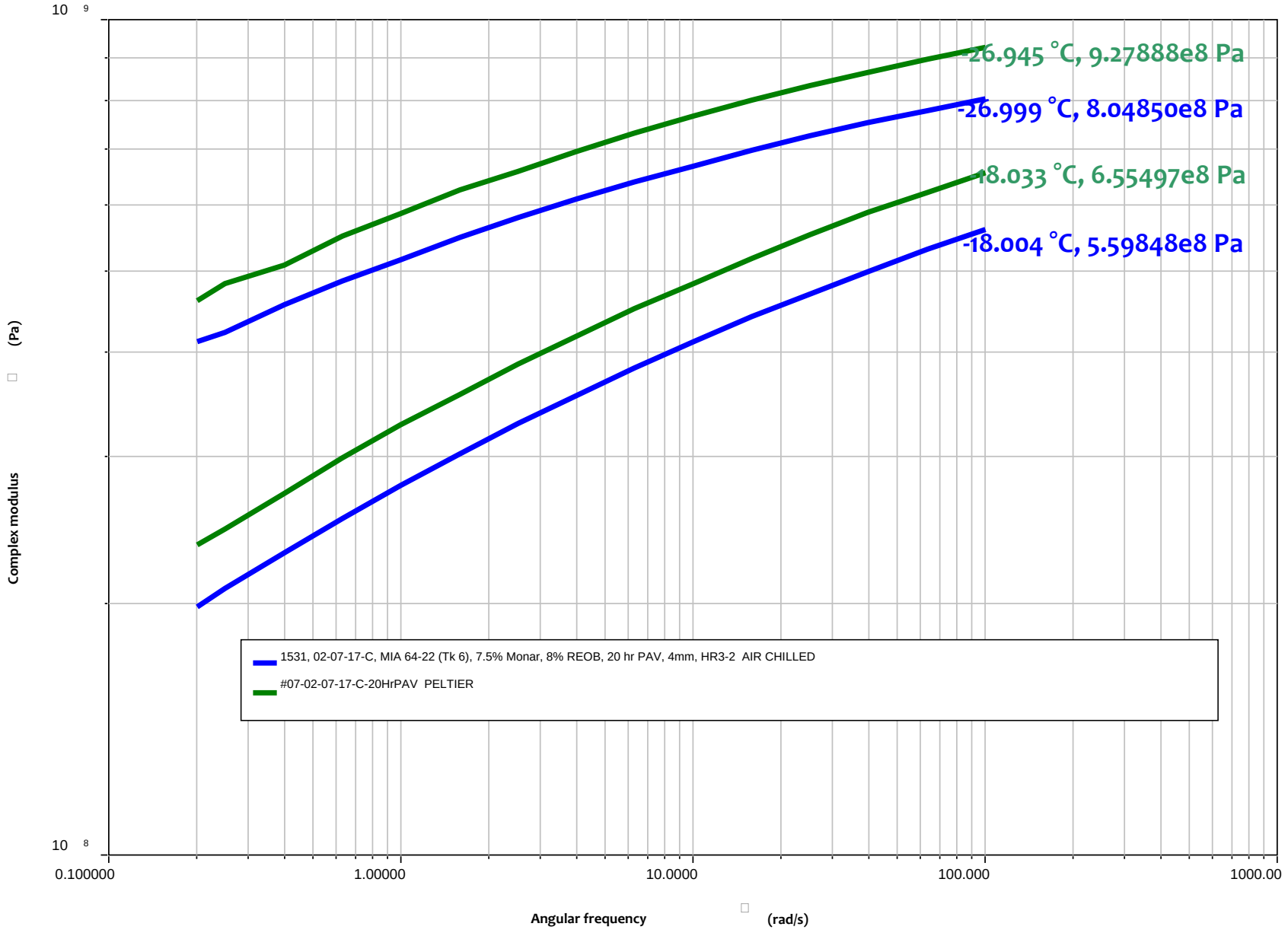
1531, 02-07-17-B, MIA 64-22 (Tk 6), 7.5% Monar, 20 hr PAV, 4mm, HR3-3



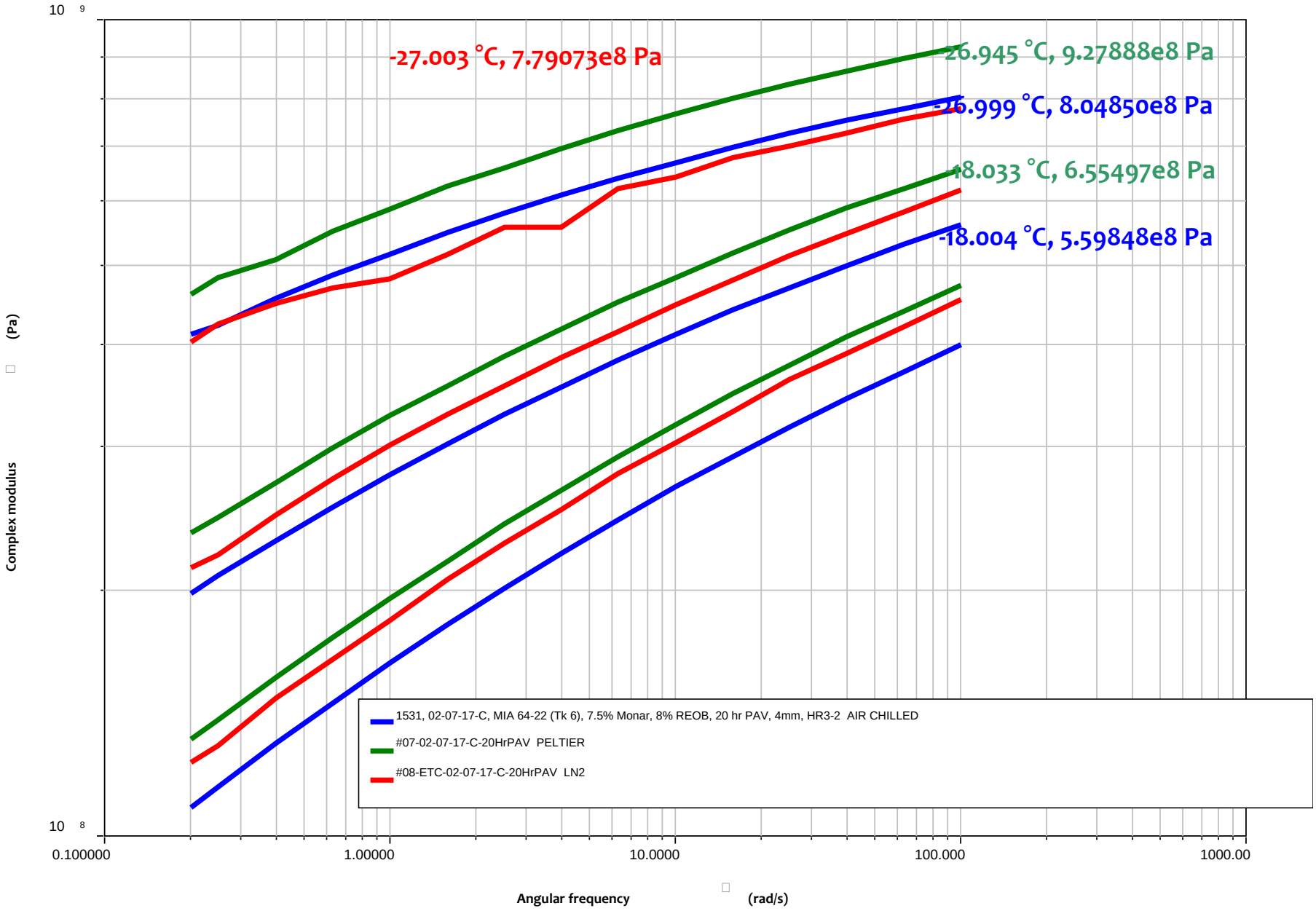
1531, 02-07-17-C, MIA 64-22 (Tk 6), 7.5% Monar, 8% REOB, 20 hr PAV, 4mm, HR3-2



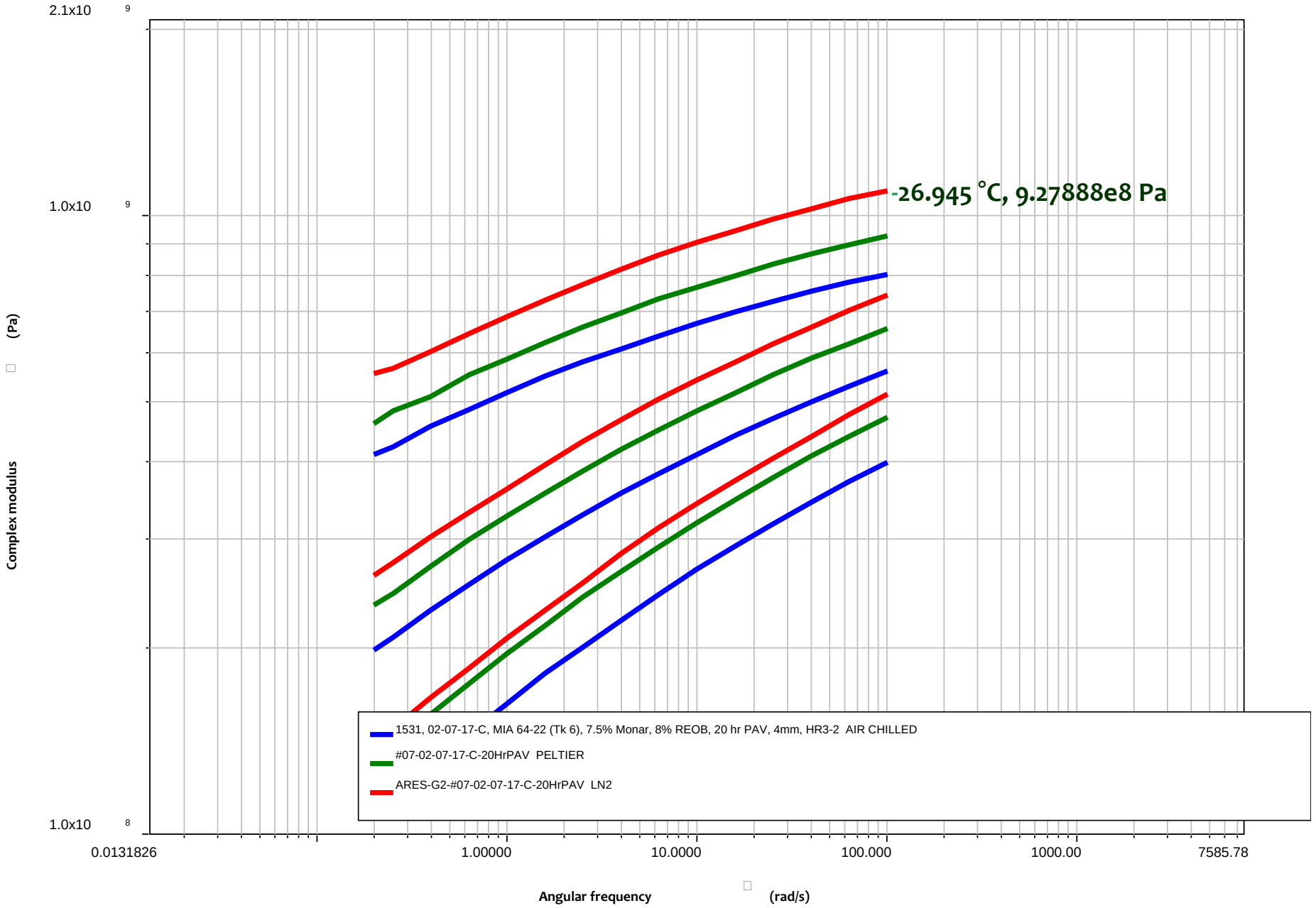
1531, 02-07-17-C, MIA 64-22 (Tk 6), 7.5% Monar, 8% REOB, 20 hr PAV, 4mm, HR3-2

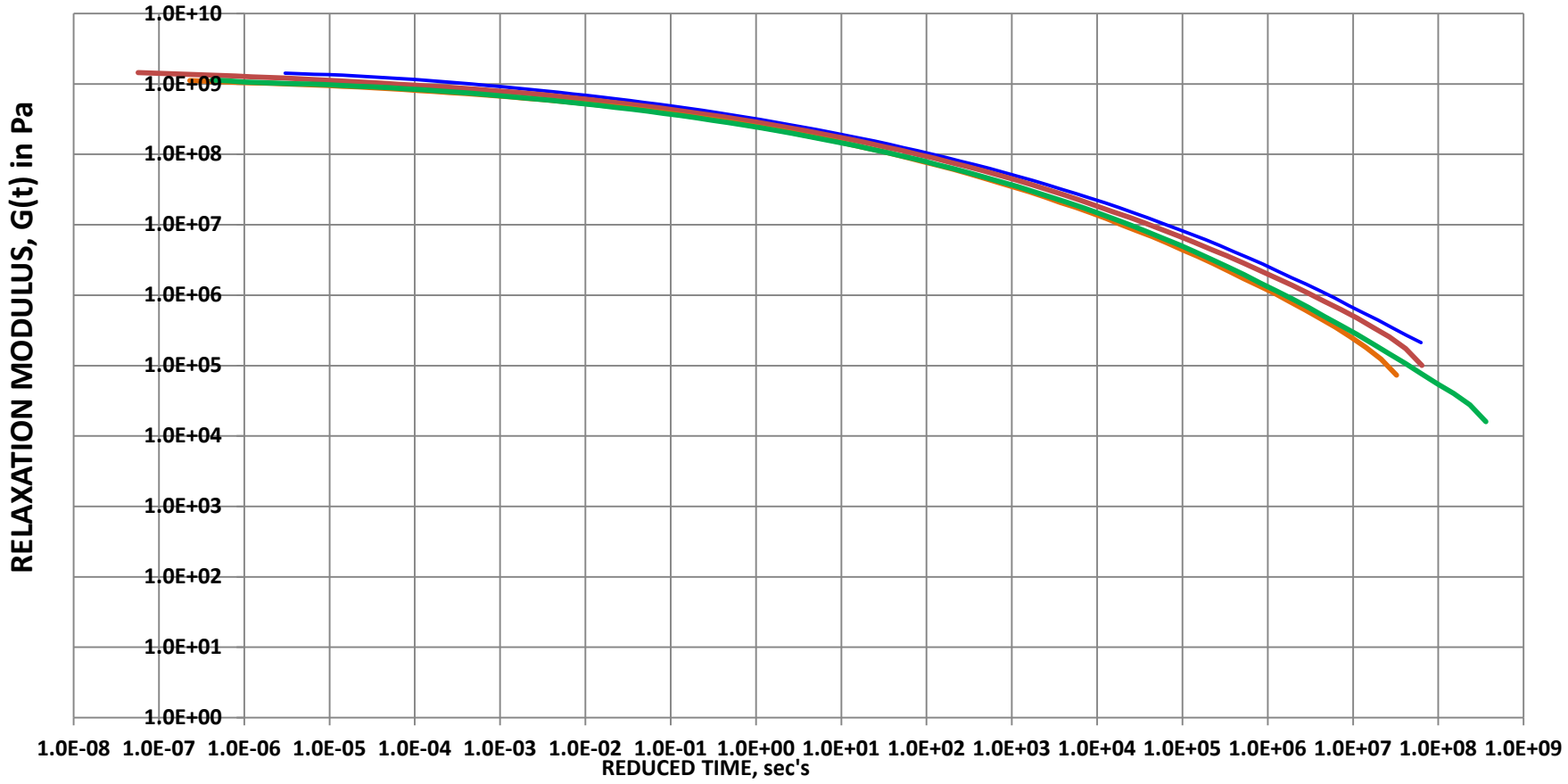


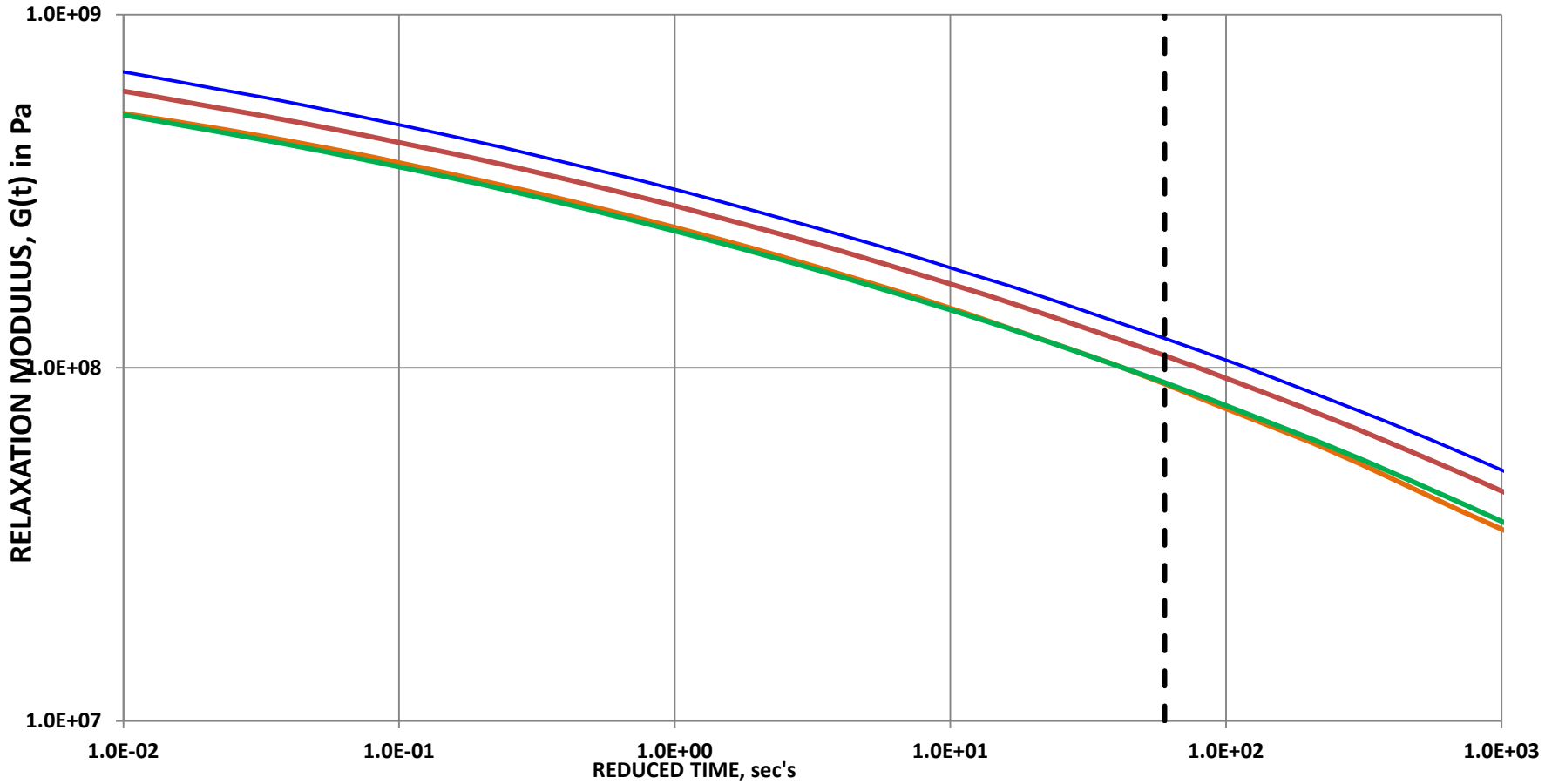
1531, 02-07-17-C, MIA 64-22 (Tk 6), 7.5% Monar, 8% REOB, 20 hr PAV, 4mm, HR3-2



1531, 02-07-17-C, MIA 64-22 (Tk 6), 7.5% Monar, 8% REOB, 20 hr PAV, 4mm, HR3-2




RELAXATION MODULUS, G(t) in Pa
1.0E+10
1.0E+09
1.0E+08
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E-08 1.0E-07 1.0E-06 1.0E-05 1.0E-04 1.0E-03 1.0E-02 1.0E-01 1.0E+00 1.0E+01 1.0E+02 1.0E+03 1.0E+04 1.0E+05 1.0E+06 1.0E+07 1.0E+08 1.0E+09
REDUCED TIME, sec's
RHEA G(t) @-18°C ARES-G2-#07-02-07-17-C-20HrPAV
RHEA G(t) @-18°C #07-02-07-17-C-20HrPAV- PELTIER
RHEA G(T) @ -18°C, #08-ETC-02-07-17-C, TA ETC
RHEA G(t) @-18°C 1531, 02-07-17-C, MIA 64-22 (Tk 6), 7.5% Monar, 8% REOB, 20 hr PAV, 4mm, HR3-2



RHEA G(t) @-18°C ARES-G2-#07-02-07-17-C-20HrPAV

RHEA G(t) @-18°C #07-02-07-17-C-20HrPAV- PELTIER

RHEA G(T) @ -18°C, #08-ETC-02-07-17-C, TA ETC

RHEA G(t) @-18°C 1531, 02-07-17-C, MIA 64-22 (Tk 6), 7.5% Monar, 8% REOB, 20 hr PAV, 4mm, HR3-2

RELAXATION MODULUS = 60 SEC

20 hr. PAV	R_values	R-Values
	TA-Peltier	MTE air chiller
02-07-17-B	2.488	2.119
02-07-17-C	2.744	2.563
	TA ARES-G2 LN2	
02-07-17-C	2.994	2.563
	ETC, with LN2	
02-07-17-C	2.093	2.563

	Data generated at TA LAB				Data generated at MTE LAB		
Sample	$T_{Scritical}$	$T_{mcritical}$	ΔTc		$T_{Scritical}$	$T_{mcritical}$	ΔTc
02-07-17-B	-23.49	-22.99	-0.50		-25.78	-25.02	-0.76
02-07-17-C	-30.40	-26.85	-3.55		-31.65	-27.32	-4.34
02-07-17-C	-29.34	-26.14	-3.20		-31.65	-27.32	-4.34
02-07-17-C	-32.25	-28.44	-3.81		-31.65	-27.32	-4.34

DISCUSSION

1. A Peltier cooled system can reach low temperature of -27°C to -30°C
2. For the system used the data suggests uniformity of temperature across specimen
3. System we used required more than 30 minutes to reach -27°C (**physical hardening concerns**)
4. Potential issues of accurate temperature calibration

DISCUSSION

5. A great deal of condensate outside the upper Peltier hood and this froze around the outside of the hood and lower area of the DSR
6. Does it make sense to develop the 4mm DSR test on a Peltier platform?
   a) Doubtful that it will replace BBR for certification
   b) Labs that focus on certification and compliance mainly use Peltier DSR
   c) 4 mm most useful and efficient for research and forensic work

DISCUSSION

7. I am willing to participate if the desire of DSR manufacturers is to try to implement on Peltier DSR
8. Our lab can supply a variety of PAV residues from past certification samples
9. My own personal feeling is that using air chilled or LN2 chilled DSR's are the most appropriate platforms
   a) Ease of loading
   b) Rapid cooling to lowest test temperature
   c) Rapid equilibrium at all isotherms (less physical hardening

Questions
Comments