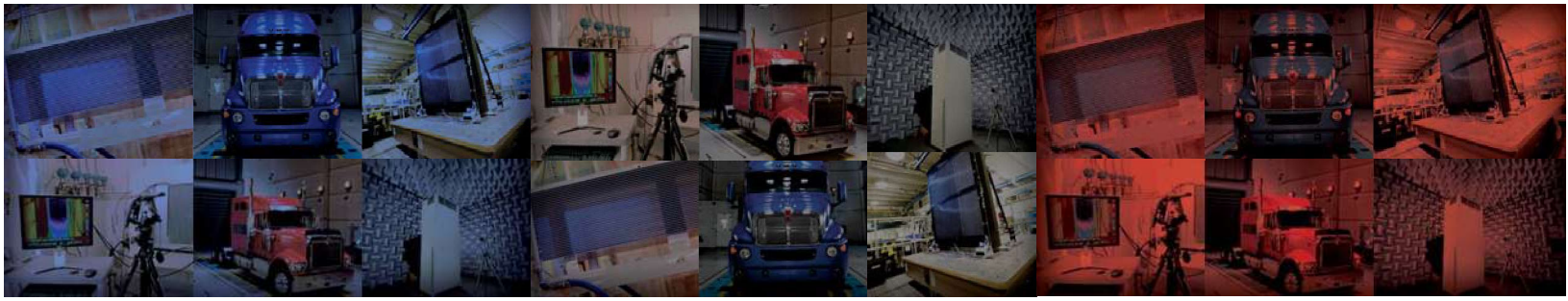


TECHNICAL CENTER
LABORATORY CAPABILITIES

MODINE®

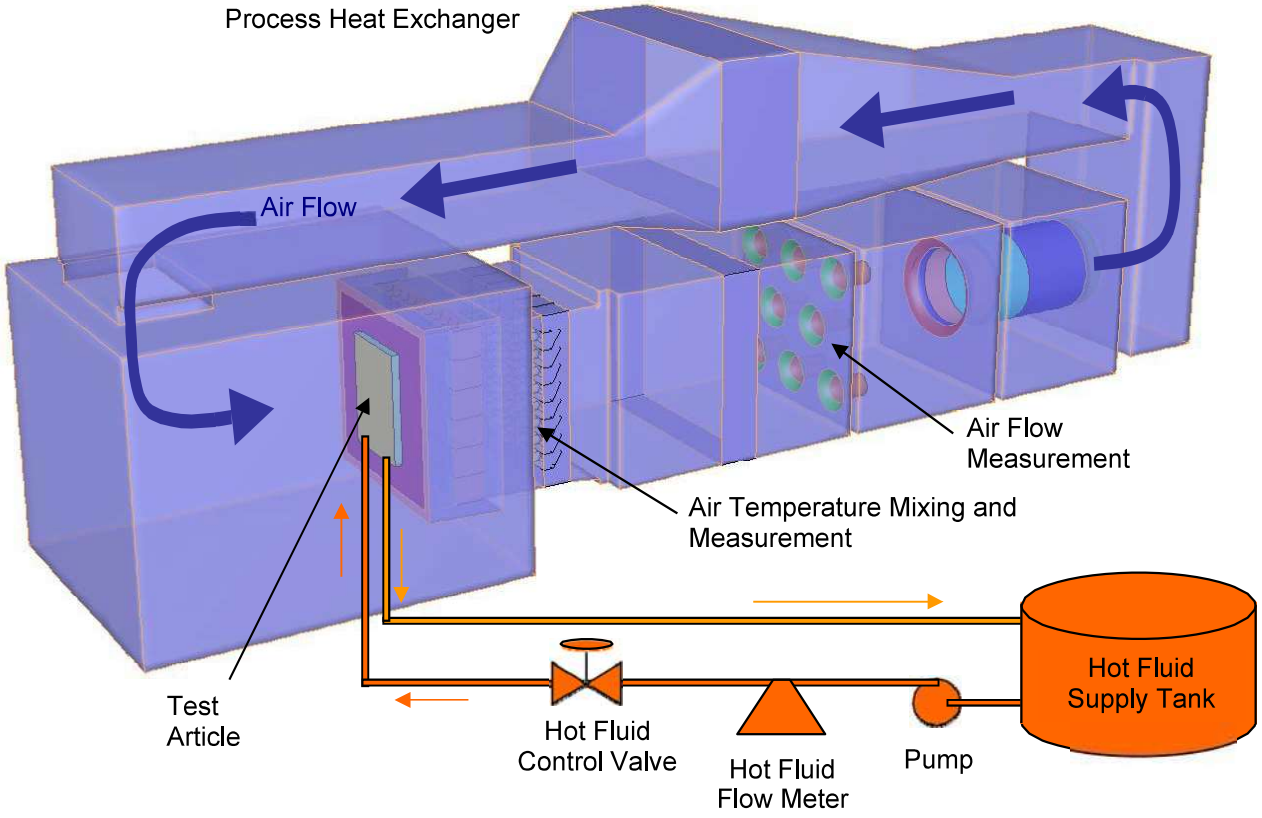
Engineering a Cleaner, Healthier World

The Racine Technical Center conducts performance and durability evaluations for heat-transfer components, modules or systems. The facility is certified to ISO 9001:2015 and is audited for compliance to requirements in IATF16949:2016 (as a remote location, providing test services for our manufactured products). Four major types of test capabilities have been established for the purpose of ensuring design adequacy for the intended use. For additional information or to request a quote for testing, please contact 1.855.654.TEST (1.855.654.8378) or email us at testing@modine.com.

Thermal Test Lab

Three separate laboratories provide calorimetry capability to support product development and validation activities. The **Refrigeration Laboratory** deals with two phase heat transfer of traditional vapor compression refrigeration cycle condensers and evaporators. **The Thermal Laboratory** deals with single phase heat transfer of radiators, charge air coolers, oil and fuel coolers, while the Exhaust Gas Recirculation Cooler **(EGRC) Laboratory** specializes in high temperature single phase heat transfer testing.

All three laboratories provide a wide variety of stable fluid inputs with flow rate, temperature, and pressure control to establish the fundamental thermodynamic characteristics of heat exchangers and systems. Information regarding operational ranges and control capability can be found below.



Calorimeters

The calorimeters are similar to the simplified diagram shown above. Various test fluids are available. Calorimeter capabilities are listed in the following tables.

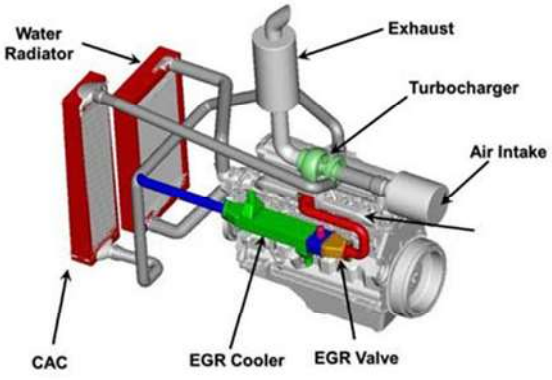
Single Phase Thermal Lab Calorimeter Capacities

Fluid Type	Minimum Flow Rate	Maximum Flow Rate	UUT Inlet Temperature	Maximum Thermal Capacity	Max. UUT Inlet Pressure	Max. UUT Pressure Drop
Thermal Lab Calorimeter Test Cell #1 – Maximum Test Article Size: 686 x 686 mm (27 x 27 in) - Ambient Humidity						
Ambient Air	410 kg/hr (200 SCFM)	6900 kg/hr (3,400 SCFM)	21-35 ºC (70-95 ºF) not controlled	Cold Fluid - 340 kW (19,300 btu/min)	Prevailing Ambient	2.5 kPa Dp (10 in H_2O)
Water	68 kg/hr (2.5 lb_m/min)	28,000 kg/hr (1,030 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 300 kW (17,100 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
50/50 EGW	68 kg/hr (2.5 lb_m/min)	30,000 kg/hr (1,100 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 340 kW (19,300 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
Type F Trans. Oil	136 kg/hr (5 lb_m/min)	5,200 kg/h (190 lb_m/min)	40-120 ºC (104-250 ºF)	Hot Fluid - 110 kW (6,300 btu/min)	450 kPa (A) (65 psia)	350 kPa Dp (50 psid)
Diesel Fuel	68 kg/hr (2.5 lb_m/min)	1,050 kg/hr (40 lb_m/min)	70-110 ºC (158-230 ºF)	Hot Fluid - 22 kW (1,300 btu/min)	410 kPa (A) (60 psia)	310 kPa Dp (45 psid)
Thermal Lab Calorimeter Test Cell #2 - Maximum Test Article Size: 1,220 x 1,220 mm (48 x 48 in) – Ambient Humidity						
Ambient Air	4,500 kg/hr (2,205 SCFM)	40,500 kg/hr (19,840 SCFM)	21-35 ºC (70-95 ºF) not controlled	Cold Fluid - 340 kW (19,300 btu/min)	Prevailing Ambient	2.5 kPa Dp (10 in H_2O)
Water	68 kg/hr (2.5 lb_m/min)	26,400 kg/hr (970 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 300 kW (17,100 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
50/50 EGW	68 kg/hr (2.5 lb_m/min)	26,400 kg/hr (970 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 340 kW (19,300 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
Charge Air	275 kg/hr (10 lb_m/min)	6,100 kg/hr (225 lb_m/min)	40-175 ºC (104-350 ºF.)	Hot Fluid - 180 kW (10,200 btu/min)	340 kPa (A) (50 psia)	240 kPa Dp (35 psid)
Thermal Lab Calorimeter Test Cell #3 - Maximum Test Article Size: 965 x 965 mm (38 x 38 in) - Ambient Humidity						
Ambient Air	1,500 kg/hr (735SCFM)	30,500 kg/hr (14,900 SCFM)	21-35 ºC (70-95 ºF) not controlled	Cold Fluid - 780 kW (44,400 btu/min)	Prevailing Ambient	2.5 kPa Dp (10 in H_2O)
Water	68 kg/hr (2.5 lb_m/min)	25,900 kg/hr (950 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 670 kW (38,100 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
50/50 EGW	68 kg/hr (2.5 lb_m/min)	26,300 kg/hr (965 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 780 kW (44,400 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
Charge Air	275 kg/hr (10 lb_m/min)	6,100 kg/hr (225 lb_m/min)	40-175 ºC (104-350 ºF.)	Hot Fluid - 180 kW (10,200 btu/min)	340 kPa (A) (50 psia)	240 kPa Dp (35 psid)
SAE30 Engine Oil	68 kg/hr (2.5 lb_m/min)	13,600 kg/hr (500 lb_m/min)	40-121 ºC (100-250 ºF)	Hot Fluid - 365 kW (21,760 btu/min)	450 kPa (A) (65 psia)	350 kPa Dp (50 psid)
Thermal Lab Calorimeter Test Cell #4 – Maximum Test Article Size: 1,830 x 1,830 m (72 x 72 in) – Ambient Humidity						
Ambient Air	3,000 kg/hr (1,470 SCFM)	61,000 kg/hr (29,800 SCFM)	21-35 ºC (70-95 ºF) not controlled	Cold Fluid - 780 kW (44,400 btu/min)	Prevailing Ambient	2.5 kPa Dp (10 in H_2O)
Water	68 kg/hr (2.5 lb_m/min)	34,800 kg/hr (1,300 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 670 kW (38,100 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
50/50 EGW	68 kg/hr (2.5 lb_m/min)	34,800 kg/hr (1,300 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 780 kW (44,400 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
SAE10 Engine Oil	68 kg/hr (2.5 lb_m/min)	22,100 kg/hr (800 lb_m/min)	40-121 ºC (104-250 ºF)	Hot Fluid - 340 kW (19,300 btu/min)	450 kPa (A) (65 psia)	350 kPa Dp (50 psid)

Single Phase Thermal Lab Calorimeter Capacities – continued						
Fluid Type	**Minimum Flow Rate**	**Maximum Flow Rate**	**UUT Inlet Temperature**	**Maximum Thermal Capacity**	**Max. UUT Inlet Pressure**	**Max. UUT Pressure Drop**
Thermal Lab Calorimeter Test Cell #5 – Maximum Test Article Size: 914 x 914 mm (36 x 36 in) - Ambient Humidity						
Ambient Air	800 kg/hr (392 SCFM)	13,700 kg/hr 6,700 SCFM)	21-35 ºC (70-95 ºF) not controlled	Cold Fluid - 780 kW (44,400 btu/min)	Prevailing Ambient	2.5 kPa Dp (10 in H2O)
Water	68 kg/hr (2.5 lb_m/min)	31,300 kg/hr (1,150 lb_m /min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 780 kW (44,400 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
50/50 EGW	68 kg/hr (2.5 lb_m/min)	36,200 kg/hr (1,330 lb_m /min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 670 kW (38,100 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
Diesel Fuel	68 kg/hr (2.5 lb_m/min)	1,100 kg/hr (40 lb_m /min)	70-110 ºC (160-230 ºF)	Hot Fluid - 22 kW (1,300 btu/min)	410 kPa (A) (60 psia)	310 kPa Dp (45 psid)
SAE10 Engine Oil	68 kg/hr (2.5 lb_m/min)	13,700 kg/hr (500 lb_m /min)	40-121 ° C (104-250 ºF)	Hot Fluid - 340 kW (19,300 btu/min)	450 kPa (A) (65 psia)	350 kPa Dp (50 psid)
SAE30 Engine Oil	68 kg/hr (2.5 lb_m/min)	13,700 kg/hr (500 lb_m /min)	40-121 ºC (100-250 ºF)	Hot Fluid - 220 kW (12,500 btu/min)	450 kPa (A) (65 psia)	350 kPa Dp (50 psid)
Thermal Lab Calorimeter Test Cell #6 – Maximum Test Article Size: 914 x 610 mm (36 x 24 in)						
Water	68 kg/hr (2.5 lb_m/min)	10,900 kg/hr (400 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Cold Fluid - 670 kW (38,100 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
50/50 EGW	68 kg/hr (2.5 lb_m/min)	10,900 kg/hr (400 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Cold Fluid - 780 kW (44,400 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
SAE30 Engine Oil	68 kg/hr (2.5 lb_m/min)	6,500 kg/hr (240 lb_m/min)	40-121 ºC (104-250 ºF)	Hot Fluid - 220 kW (12,500 btu/min)	450 kPa (A) (65 psia)	350 kPa Dp (50 psid)
Thermal Lab Calorimeter Test Cell #7 – Maximum Test Article Size: 1,220 x 610 mm (48 x 24 in)						
Water	68 kg/hr (2.5 lb_m/min)	35,400 kg/hr (1,300 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Cold Fluid - 670 kW (38,100 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
50/50 EGW	68 kg/hr (2.5 lb_m/min)	35,400 kg/hr (1,300 lb_m/min)	82 ±1.5 ºC (180 ±3.0 ºF)	Hot Fluid - 670 kW (38,100 btu/min)	310 kPa (A) (45 psia)	210 kPa Dp (30 psid)
SAE 30	68 kg/hr (2.5 lb_m/min)	20,000 kg/hr (735 lb_m/min)	27-121 ºC (80-250 ºF)	Hot Fluid - 340 kW (19,300 btu/min)	450 kPa (A) (65 psia)	350 kPa Dp (50 psid)
SAE 10	68 kg/hr (2.5 lb_m/min)	19,700 kg/hr (725 lb_m/min)	27-121 ºC (80-250 ºF)	Hot Fluid - 340 kW (19,300 btu/min)	450 kPa (A) (65 psia)	350 kPa Dp (50 psid)
Diesel Fuel	68 kg/hr (2.5 lb_m/min)	1,050 kg/hr (40 lb_m/min)	70-110 ºC (158-230 ºF)	Hot Fluid - 22 kW (1,300 btu/min)	410 kPa (A) (60 psia)	310 kPa Dp (45 psid)

Single Phase Exhaust Gas Recirculation Cooler (EGRC) Lab Calorimeter Capacities						
Fluid Type	**Maximum Flow Rate**	**UUT Inlet Temperature**	**Maximum Thermal Capacity**		**Max. UUT Inlet Pressure**	**Max. UUT Pressure Drop**
EGRC Lab Calorimeter Test Cell #1 - Maximum Test Article Size With Test Fixture: 914 x 457 x 457 mm (36 L x 18 H x 18 D in)						
Compressed Air	18 kg/min (40 lb_m /min)	30-700 ºC (86-1,290 °F)	Hot Fluid:	150 kW (8,500 btu/min)	152 kPa (G) (22 psig)	35 kPa Dp (5 psid)
50/50 EGW	100 l/min (26 gpm)	30-110 ºC (86-230 °F)	Cold Fluid:	150 kW (8,500 btu/min)	345 kPa (G) (50 psig)	200 kPa Dp (29 psid)
EGRC Lab Calorimeter Test Cell #2 - Maximum Test Article Size With Test Fixture: 1,219 x 610 x 457 mm (48 L x 24 H x 18 D in)						
Compressed Air	18 kg/min (40 lb_m /min)	30-700 °C (86-1,290 °F)	Hot Fluid:	150 kW (8,500 btu/min)	152 kPa (G) (22 psig)	35 kPa Dp (5 psid)
50/50 EGW	375 l/min (99 gpm)	30-110 ºC (86-230 °F)	Cold Fluid:	150 kW (8,500 btu/min)	345 kPa (G) (50 psig)	200 kPa Dp (29 psid)
EGRC Lab Calorimeter Test Cell #3 - Maximum Test Article Size With Test Fixture: 1,219 x 610 x 457 mm (48 L x 24 H x 18 D in)						
Compressed Air	18 kg/min (40 lb_m/min)	30-800 ºC (86-1470 °F)	Hot Fluid:	220 kW (12,500 btu/min)	152 kPa (G) (22 psig)	35 kPa Dp (5 psid)
50/50 EGW	350 l/min (92 gpm)	30-110 ºC (86-230 °F)	Cold Fluid:	220 kW (12,500 btu/min)	345 kPa (G) (50 psig)	200 kPa Dp (29 psid)
EGRC Lab Calorimeter Test Cell #4 - Maximum Test Article Size With Test Fixture: 1,219 x 610 x 457 mm (48 L x 24 H x 18 D in)						
Compressed Air	18 kg/min (40 lb_m/min)	30-800 ºC (86-1470 °F)	Hot Fluid:	220 kW (12,500 btu/min)	152 kPa (G) (22 psig)	35 kPa Dp (5 psid)
50/50 EGW	350 l/min (92 gpm)	30-110 ºC (86-230 °F)	Cold Fluid:	220 kW (12,500 btu/min)	345 kPa (G) (50 psig)	200 kPa d (29 psid)
EGRC Lab Calorimeter Test Cell #6 - Maximum Test Article Size With Test Fixture: 1,219 x 610 x 610 mm (48 L x 24 H x 24 D in)						
Compressed Air	18 kg/min (40 lb_m/min)	30-800 ºC (86-1470 °F)	Hot Fluid:	220 kW (12,500 btu/min)	152 kPa (G) (22 psig)	35 kPa Dp (5 psid)
50/50 EGW	300 l/min (80 gpm)	30-110 ºC (86-230 °F)	Cold Fluid:	220 kW (12,500 btu/min)	345 kPa (G) (50 psig)	200 kPa Dp (29 psid)
Note: The EGRC Lab Calorimeter Test Cells are also used for thermal cycle durability tests. Please refer to the Structural Test Lab section for thermal cycle capabilities.						

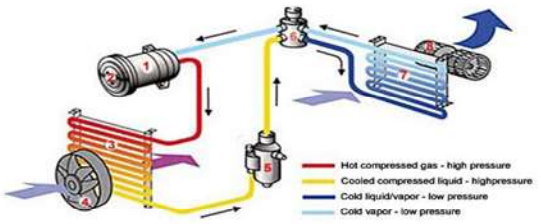
Diagram of Engine with an EGR Cooler



Two Phase (Refrigeration) Calorimeter Capacities					
Fluid Type	**Maximum Flow Rate**	**UUT Inlet Temperature**	**Maximum Thermal Capacity**	**Max. UUT Inlet Pressure**	**Max. UUT Pressure Drop**
Ambient Air	3,420 m^3/hr (2,000 CFM)	Dry Bulb: 20-50 ºC (68-122 ºF) Humidity: 10-90 % Rh (DB Dependent) Dew Point: (-11)-35 ºC (12-95 ºF)	12 kW (42,000 btu/hr)	Prevailing Ambient	1 kPa Dp (4 in H_2O Dp)
R-410a Liquid (Evaporator Testing)	370 kg/hr (816 lb_m/hr)	Inlet SC: 0.5-22 ºC (1-40 ºF) Outlet SH: 3-28 ºC (5-50 ºF)		BFXV: 2,000-4,500 kPa (G) (285-645 psig) Inlet: 276-1,140 kPa (G) (40-165 psig) Outlet: 244-1,140 kPa (G) (35-165 psig)	690 kPa Dp (100 psid)
Refrigeration Lab Calorimeter Test Cell #2 - Max. Test Article Size: 1,067 x 1,067 mm (40 x 40 in) - Controlled Humidity					
Ambient Air	10,200 m^3/hr (6,000 CFM)	Dry Bulb : 20-50 ºC (68-122 ºF) Humidity: 10-90 % Rh (DB Dependent)	17.5 kW (60,000 btu/hr)	Prevailing Ambient	1.0 kPa Dp (4 in H_2O Dp)
R-410a Vapor (Condenser testing)	370 kg/hr (816 lb_m/hr)	Inlet SH: 17-84 ºC (30-150 ºF) Outlet SC: 0.5-28 ºC (1-50 ºF)		2,000-4,500 kPa (G) (280-640 psig)	414 kPa Dp (60 psid)
Refrigeration Lab Calorimeter Test Cell #3 - Max. Test Article Size: 1,067 x 1,067 mm (42 x 42 in) - Ambient Humidity					
Ambient Air	10,200 m^3/hr (6,000 CFM)	20-50 ºC (68-122 ºF)	17.5 kW (60,000 btu/hr)	Prevailing Ambient	1.0 kPa Dp (4 in H_2O Dp)
R-134a Vapor (Condenser testing)	400 kg/hr (900 lb_m/hr)	Inlet SH: 6-56 ºC (10-100 ºF) Outlet SC: 0.6-28 ºC (1-50 ºF)		1,034-2,068 kPa (G) (150-300 psig)	414 kPa Dp (60 psid)
50/50 EGW	2,180 kg/hr (80 lb_m/min)	15-95 ºC (60-205 ºF)		138 kPa (G) (20 psig)	62 kPa Dp (9 psid)
Refrigeration Lab Calorimeter Test Cell #4 - Battery Chiller Testing					
R-134a Liquid (Evaporator testing)	272 kg/hr (600 lb_m/hr)	Inlet SC: Outlet SH: 0 (flooded)-17 ºC (0 (flooded)-30 ºF)	12 kW (42,100 btu/hr)	BFXV: 690-1,900 kPa (G) (100-280 psig) Inlet: 170-410 kPa (G) (25-60 psig) Outlet: 140-410 kPa (G) (20-60 psig)	690 kPa Dp (100 psid)
50/50 EGW	2,180 kg/hr (80 lb_m /min)	15-95 ºC (60-205 ºF)		138 kPa (G) (20 psig)	62 kPa Dp (9 psid)

Refrigeration Cycle

1. Compressor
2. Compressor Clutch
3. Condensor
4. Condensor Fan
5. Receiver/Drier
6. Expanson Valve
7. Evaporator
8. Dash Blower Motor



Structural Test Lab

Equipment in these laboratories is used to assess durability and reliability of products, components and assemblies under a variety of loading scenarios. Products need to meet the dynamic and damaging forces that they endure during stationary or on & off highway use. Those forces are derived from changing hot/cold temperature conditions and harsh vibration events. Tests include vibration (multi-axis and single axis), shock, pressure cycle, thermal cycle, hydrostatic burst test, and field data acquisition.

VIBRATION

Multi Axis Simulation Table (MAST): Multi-axis simulation is used to closely simulate a field operating environment or a defined vibration profile requirement. The test procedure is generally used to evaluate durability of systems and components under the mixed loading encountered in the field. The MAST system can reproduce field inputs through 6 Degree-of-Freedom motion (Longitudinal, Lateral, Vertical, Roll, Pitch and Yaw). Compared to full vehicle proving ground testing, MAST tests are conducted using only the components of interest and development timelines can be reduced by elimination of non-damaging sections and continuous testing.

ITEM	MAST #1		MAST #2		MAST #3	
Degrees of Freedom	6 (Vertical, Longitudinal, Lateral, Roll, Pitch and Yaw)		6 (Vertical, Longitudinal, Lateral, Roll, Pitch and Yaw)		6 (Vertical, Longitudinal, Lateral, Roll, Pitch and Yaw)	
Frequency Range	0.5 to 65 Hz		0.5 to 65 Hz		0.5 to 65 Hz	
Force	Vertical	48.9 kN (11 kip)	Vertical	48.9 kN (11 kip)	Vertical	48.9 kN (11 kip)
	Lateral	24.5 kN (5.5 kip)	Lateral	35.6 kN (8 kip)	Lateral	35.6 kN (8 kip)
	Longitudinal	24.5 kN (5.5 kip)	Longitudinal	48.9 kN (11 kip)	Longitudinal	48.9 kN (11 kip)
Displacement	Vertical	± 76 mm (±3 in)	Vertical	± 127 mm (±5 in)	Vertical	± 127 mm (±5 in)
	Lateral	± 76 mm (±3 in)	Lateral	± 76 mm (±3 in)	Lateral	± 76 mm (±3 in)
	Longitudinal	± 76 mm (±3 in)	Longitudinal	± 76 mm (±3 in)	Longitudinal	± 76 mm (±3 in)
Weight Capabilities	499 kg (1,100 lb)		816 kg (1,800 lb)		816 kg (1,800 lb)	
Table Size	1.5 x 1.8 m (60 x 72 in)		1.5 x 1.8 m (60 x 72 in)		1.5 x 2.1 m (60 x 84 in)	
Mounting Hole	M12, 100 mm centers		M12, 100 mm centers		M12, 100 mm centers	
Number of Channels	15		15		15	

Single Axis – Hydraulic: Single axis actuator #1 & #2 are configured for vertical displacement and acceleration. Fixtures can be fabricated to restrain the unit under test (UUT) in horizontal mounting orientations. MTS FlexTest IIM controllers and software are used for displacement control or system can be run in acceleration control using the Vibration Research VR8500 controller.

Connection Test Station: Single axis actuator #3 is used with special fixturing to allow directional configuration as required to match test specific requirements. Capabilities are listed below. MTS FlexTest IIM controllers and software are used for displacement or load control.

ITEM	Actuator #1	Actuator #2	Actuator #3
Degrees of Freedom	Single axis (vertical plate)	Single axis (horizontal table)	Single axis
Frequency Range	5 - 90 Hz	5 - 90 Hz	0.1 to 10 Hz
Force	48.9 kN (11 kip)	98 kN (22 kip)	9.8 kN (2.2 kip)
Displacement	± 76 mm (±3 in)	± 76 mm (±3 in)	± 76 mm (±3 in)
Table Size	914 x 914 mm (36 x 36 in)	1,200 x 1,200 mm (47 x 47 in) with M12 holes on 100 mm (3.94 in) centers, (90 mm outer row)	n/a
Number of Channels	4	4	4

High Frequency Vibration: Unholtz–Dickie electro-dynamic shaker and slip tables.
Control capability: Sine, Random, Sine on Random, Sine Dwell and Shock.

ITEM	Table #1	Table #2
Degrees of Freedom	Single axis: vertical or horizontal	Single axis: vertical or horizontal
Frequency Range	5 - 2,000 Hz	5 - 2,000 Hz
Force	31.1 kN (7,000 force-lbs.) peak sine rating 17.8 kN (4,000 force-lbs.) rms random	89 kN (20,000 force-lbs.) peak sine rating 89 kN (20,000 force-lbs.) rms random
Displacement	± 12.7 mm (0.5 in); 25 mm (1.0 in) Total	± 25 mm (1.0 in); 50 mm (2.0 in) Total
Weight Capabilities	136 kg (300 lb) 23 kg (50 lbs.) armature	907 kg (2,000 lb) 40 kg (90 lbs.) armature
Table Size	Vertical armature head - 305 mm (12 in) Dia. Horizontal slip table - 1,150 x 1220 mm (45 x 48 in)	Vertical armature head - 406 mm (16 in) Dia. Vertical head expander - 1,220 x 1,220 mm (48 x 48 in) Horizontal slip table - 1,220 x 1,220 mm (48 x 48 in)
Mounting Hole	M12 holes on 100 mm (3.94 in) centers 1100 mm x 1100 mm (43.3x43.3 in)	M12 holes on 100 mm (3.94 in) centers 1100 mm x 1100 mm (43.3x43.3 in)
Number of Channels	8	12

PRESSURE CYCLE

ITEM	**Low Pressure Cycle – Glycol** (2 Rigs)	**Low Pressure Cycle – Glycol** (2 Rigs)	**High Pressure Cycle – Glycol** (4 Rigs)
Chamber Size	762 x 2,184 x 965 mm (30 x 86 x 38 in) 1371 x 2184 x 2134 mm (56 x 86 x 84 in)	1371 x 2184 x 2134 mm (56 x 86 x 84 in)	1371 x 2,032 x 2,286 mm (54 x 80 x 90 in)
Fluid	Glycol	Glycol	Glycol
Pressure	0 - 400 kPa (G) (0 - 58 psig)	0 - 310 kPa (G) (0 - 45 psig)	7 - 5,520 kPa (G) (1 - 800 psig)
Frequency	0.015 - 0.5 Hz	0.015 - 0.5 Hz	0.1 - 15 Hz
Temperature	Max 121 °C (250 °F)	Max 121 °C (250 °F)	Max 82 °C (180 °F)
Capacity	Up to 6 test articles in each test rig	Up to 6 test articles in each test rig	Up to 6 test articles in each test rig

ITEM	**High Pressure Cycle** Heat Chamber #1	**High Pressure Cycle** Heat Chamber #2	**High Pressure Cycle** Environmental Chamber #2
Chamber Size	914 x 914 x 914 mm (36 x 36 x 36 in)	1,190 x 890 x 1,295 mm (47 x 35 x 51 in)	910 x 910 x 910 mm (36 x 36 x 36 in)
Fluid	Mobiltherm 43	Mobiltherm 43 or Glycol	Mobiltherm 43
Pressure	7 - 5,520 kPa (G) (1 - 800 psig)	7 - 5,520 kPa (G) (1 - 800 psig)	7 - 17,240 kPa (G) (1 - 2,500 psig)
Frequency	0.1 - 10 Hz	0.1 - 10 Hz	0.1 - 10 Hz
Temperature	Max 150 °C (302 °F)	Max 150 °C (302 °F) for Mobiltherm 43 or 90°C (194°) for Glycol	-35 °C - 150 °C (-31 °F to 302 °F)
Capacity	Up to 6 test articles	Up to 6 test articles	Up to 6 test articles

ITEM	**Air Pressure Cycle** Heated Air Chamber
Chamber Size	1,830 x 1,520 x 1,220 mm (72 x 60 x 48 in)
Fluid	Compressed Air
Pressure	7 - 414 kPa (G) (1 - 60 psig)
Frequency	0.2 - 1 Hz
Temperature	150 - 232 °C (302 - 450 °F)
Capacity	Up to 5 test articles - individual pressure for each test article at same ambient temperature

ITEM	**Hydrostatic Burst Test** Test Article Filled Water and Pressurized
Pressure	0 - 55.2 MPa (G) (0 - 8,000 psig)
Temperature	ambient air to 150 °C (302 °F)

THERMAL CYCLE

ITEM	Air Thermal Cycle - with optional constant air flow	Air Thermal Cycle - with optional constant liquid flow
Primary Fluid	Air from Centrifugal blower	Air from 4 stage blower
Frequency	1 min/cycle - 5 min/cycle	1 min/cycle - 5 min/cycle
Ramp Rate	49 - 260 °C (120 - 500 °F) in less than 30 sec. at inlet of test article	49 - 260 °C (120 - 500 °F) in less than 30 sec. at inlet of test article
Temperature Range	43 - 300 °C (110 - 572 °F)	2 cells - 49 - 300 °C (120 - 572 °F) 1 cell - 49 - 330 °C (120 - 626 °F)
Air Mass Flow	300 -1,800 kg/hr (11 - 66 lbs/min) of charge air flow during hot cycle	500 - 2,000 kg/hr (18 - 73 lb/min) of charge air flow during hot cycle
Secondary Fluid	Ambient air from ceiling mounted chamber fan can draw across the core	50/50 glycol and water by volume from pump skids
Secondary Fluid Flow	Up to 6,780 SCMH (4,000 SCFM) air	10 to 150 L/min - Ethylene glycol/ water-inlet temperature (20 to 90 °C)
Leak Test	Automated by pressure decay completed during test at set intervals	Automated by pressure decay completed during test at set intervals
Capacity	3 test rigs - without airflow - 1524 x 1829 x 1829 mm (80 x 118 x 84 in) with airflow - 1,225 x 1,225 mm (48 x 48 in)	3 test rigs - 2030 x 3,000 x 2134 mm (89 x 118 x 84 in)

ITEM	Environmental Chamber 1 Thermal Cycle	Environmental Chamber 2 Thermal Cycle
Chamber Size	1,000 x 900 x 1,000 mm (39 x 35 x 39 in)	1,200 x 1,200 x 1,320 mm (48 x 48 x 52 in)
Temperature Range	(-40) - 149 °C ((-40) - 300 °F)	(-70) - 180 °C ((-94) - 356 °F)
Controls	Programmable chamber temperature controller to handle cycling, ramp rates, soak times	Programmable chamber temperature controller to handle cycling, ramp rates, soak times
Ramp Rate	35 kg (75 lbs), from (-40) - 110 °C ((-40) - 230 °F) in 1 hour	Empty chamber air temperature can ramp from (-70) to 180°C ((-94) to 356 °F) in 1 hour
Pressure	Pneumatic regulator to maintain test article at constant pressure as temperature changes	Pneumatic regulator to maintain test article at constant pressure as temperature changes
Leak Test	Failure is detectable by leak only	Failure is detectable by leak only
Instrumentation	Standard 4 channels of thermocouples (including chamber)	Up to 9 thermocouple channels (including chamber) and 8 analog inputs (±10V)
Data Storage	1/sec to 1/hour	Minimum recording rate 0.1 minutes per sample

ITEM	Liquid Thermal Cycle – 50/50 EGW	Liquid Thermal Cycle – 50/50 EGW	Liquid Thermal Cycle – 50/50 EGW	Liquid Thermal Cycle – ATF+4 Oil
Fluid Flow	11 - 170 l/min (3 - 45 gpm)	27 - 284 l/min (7 - 75 gpm)	up to 946 l/min (250 GPM) total, divided by 4 stations	9 - 80 l/min (2.3 - 21 gpm)
Pressure	Nominal 69 - 103 kPa (G) (10 -15 psig)	Nominal 69 - 103 kPa (G) (10 -15 psig)	Nominal 69 - 103 kPa (G) (10 -15 psig)	Nominal 345 - 690 kPa (G) (50 - 100 psig)
Cycle Rate	1 - 3 minutes, dependent upon test conditions	1 - 3 minutes, dependent upon test conditions	1 - 3 minutes, dependent upon test conditions	2 - 5 minutes, dependent upon test conditions
Max Cycle Rate	~ 2 cycles/min which occurs with higher liquid flow rates, pressure under 103 kPa (G) (15 psig) and temperature range of 24 - 99 °C (70 - 210 °F)	~ 2 cycles/min which occurs with higher liquid flow rates, pressure under 103 kPa (G) (15 psig) and temperature range of 24 - 99 °C (70 - 210 °F)	1 cycle/min	0.5 cycle/min
Temperature	24 - 107 °C (75 - 225 °F)	24 - 107 °C (75 - 225 °F)	24 - 107 °C (75 - 225 °F)	24 - 135 °C (75 - 275 °F)
Maximum Temp Ramp	19.4 °C/sec (35 °F/sec)	19.4 °C/sec (35 °F/sec)	10 °C/sec (18 °F/sec)	12 °C/sec (22 °F/sec)
Capacity	Up to 3 test articles	Up to 6 test articles in two test rigs	Up to 4 test articles	Up to 3 test articles
Optional	Constant hot fluid with additional pump skid	Constant hot fluid with additional pump skid		

ITEM	Air Thermal Cycle (EGRC) - High Temperature Compressed Air to EGW
Three air supply streams	• Unconditioned compressed air at 27 - 38 °C (81 - 100 °F) • Indirect, gas-fired heated compressed air up to 800 °C (1,470 °F)
Coolant	50/50 ethylene glycol and DI water by volume
Coolant temperature	30 - 110 °C (86 - 230 °F)
Max. coolant flow	500 l/min (157 gpm)
Dual coolant flow	on one test rig
Conditions can be controlled within physical limits	• Air temperature & air temperature ramp rate • Air flow rate • Coolant inlet temperature • Coolant flow rate • Coolant inlet pressure
Fastest ramp	49 - 704 °C (120 - 1,300 °F) in less than 5 seconds at the EGRC inlet (dependent on airflow rate)
Air flow rate	0.2 - 18 kg/min (0.44 - 40 lbs/min).
Capacity	3 cells with 1,200 x 1,200 mm (47 x 47 in) 3 cells - 3,000 x 3,000 mm (118 x 118 in)

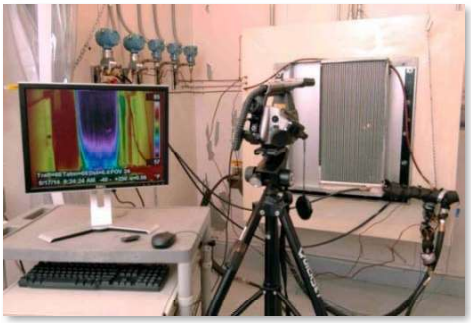
ITEM	Plastic Tank Aging Rig
Standard Fluid	50/50 glycol/water mix
Optional Fluid	Customer supplied/specified fluid with pre-approval
Standard Constant Temperature	Max 121°C (250°F)
Duration	20 - 120 days
Flowrate	8 - 20 lpm (2 - 5 gpm) each station
Pressure	120 kPa (G) (17.5 psi)
Additional Testing	Low pressure cycle testing to follow
Capacity	1 cell with 4 stations (all require the same flow rate)

EROSION CORROSION LAB

ITEM	Internal Erosion-Corrosion Cycle (2 Rigs)
Fluids	• Standard depleted coolant (30% Modine MC-2002 / 70% ASTM D1384 corrosive water) • ASTM D-1384 corrosive water (per GE0108) • OY water • ASTM D1193-91 Type IV deionized water
Flow Rate	Max 100 GPM (dependent upon test article characteristics)
Frequency	Constant Flow
Temperature	Max 121 °C (210 °F)
Capacity	Up to 2 test articles (Rig #8) Up to 6 test articles (Rig #9)

INFRA-RED - THERMAL IMAGE CAMERA

ITEM	FLIR System
Model	T450SC camera with built-in 18 mm/24° lens
Resolution	320 × 240 pixels
Temperature	Max 121 °C (250 °F)
Range	Measures from -40 to 1,500 °C (-40 to 2,730 °F)
Features	•Single picture, or video up to 30 frames/sec •USB radiometric digital output •Researcher software for post analysis •Wide angle lens (FLIR 10mm/45° Lens)



FIELD DATA ACQUISITION

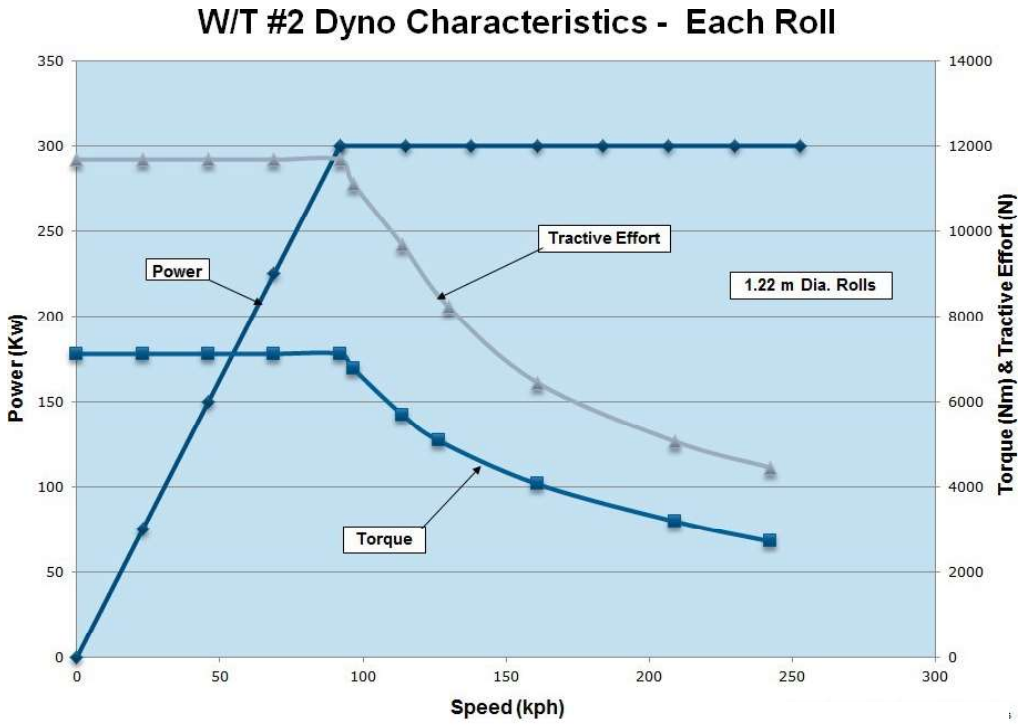
SoMat eDAQ	
Description	Four systems – each one has a thermocouple layer and two bridge voltage layers, systems can be networked for a maximum number of channels. GPS and CAN data channels available, 16 channel high level layer with modules for 120 Ω gages and ICP accelerometers.
Frequency	0.1 to 10,000 Hz sample rates/channel available
Power	Can be powered by either 12V DC or 110V AC
Temperature	32 temperature channels available per thermocouple layer in two groups of 16. Each group of 16 must be the same type (T, J, or K)
Analog	16 analog voltage channels available per bridge voltage layer. These include 350 ohm strain gages with quarter bridge completion, pressure transducers, capacitive accelerometers, and any other low level (± 10V) voltage signal
Pulse	Six pulse counter channels available per digital layer. These include turbine meters for measuring flow and optical sensors for measuring RPMs

Vehicle Test Lab

This laboratory is used to assess the performance of internal combustion engine and electric vehicles with a focus on the performance of vehicle thermal management systems. Tests range from performance evaluations of engine, electric motor, and battery thermal management systems, to vehicle cabin comfort and performance. Test are conducted in the climatic wind tunnels, the vehicle prep area, and the climatic soak room. The climatic wind tunnel has a wide range of environmental simulation capabilities.

The “vehicle” test lab is also used for non-vehicle applications (generators, roof top HVAC&R units, study impact of wind on test article, cold start testing, etc.).

Climatic Wind Tunnel Capabilities	
Controlled Criteria	Range of Capability
Temperature	-34 to 55 °C (-30 to 131 °F) Steady State Controllability: ± 0.56 °C (±1 °F) Steady State Uniformity: ± 1% Standard Dev
Humidity	10 - 90% Rh (Controlled above 4 °C (39 °F)) Steady State Controllability: ± 2% Steady State Uniformity: ± 1%
Airflow Speed - Large Vehicle	0 - 100 km/h (0 - 62 mph) Steady State Controllability: ±1.6 km/hr Steady State Uniformity: ± 2% Standard Dev
Airflow Speed - Small Vehicle	0 - 241 km/h (0 - 150 mph) Steady State Controllability: ±1.6 km/hr Steady State Uniformity: ±1% Standard Dev
Powertrain Configuration	Front Wheel Drive, Rear Wheel Drive, 4 Wheel Drive & Tandem Axle Drive 1,300 mm (50 in) minimum centerline
Vehicle Size – Maximum	14 L x 4.2 W x 4.1 H m (46 L x 14 W x 13.5 H ft)
Solar Simulation	Full Spectrum Solar Simulation (1,270 W/m^2 max) Std Irradiance area: 6.7 L x 2.6 W m (22 x 8.5 ft) Adjustable translation and angle of array sections
Vehicle Restraint System	Frame-to-Anchor Chain & Cable System
Vehicle Exhaust System	Powered Exhaust Ports
Floor Loading	17,690 kg (39,000 lbs)

Climatic Wind Tunnel Capabilities Cont.	
Dynamometer Capacity Max.	597 kW (800 HP), 298 kW (400 HP) per axle
	
Dynamometer Tractive Effort Max.	Absorbing & Motoring: 11,681 N (2,626 Lb_f) per axle - (See graph above)
Dynamometer Dynamics	Motoring and Absorbing w/Road Load & Grade Simulation
Data Acquisition System	Modular Independent DAQ System - 128 Configurable Thermocouple Inputs - 48 Configurable Analog Inputs - 8 Configurable Frequency/Counter Inputs - 4 CAN Bus Input/Outputs - Unlimited Calculation Channels

Climatic Chamber #1 Capabilities	
This large climatic chamber is used for the testing of products under a variety of environmental conditions. This lab is used for hot or cold vehicle soaks as well as for large HVACR applications testing such as rooftop units.	
Controlled Criteria	Range of Capability
Temperature	(- 40) - 60 °C ((- 40) - 140 °F) Steady State Controllability: ± 0.56 °C (1 °F)
Humidity	10 - 90% Rh (Controlled above 4 °C (39 °F)) Steady State Controllability: ± 1%
Vehicle Size - maximum	14 L x 4.2 W x 4.1 H m (46 L x 14 W x 13.5 H ft)
Vehicle Exhaust System	Powered Exhaust Ports
HVAC&R Testing	
Outdoor Temperature	(- 40) - 60 °C ((- 40) - 140 °F) Steady State Controllability: ± 0.56 °C (1 °F)
Outdoor Humidity	10 - 90% Rh (Controlled above 4 °C (39 °F)) Steady State Controllability: ± 1%
Indoor (Return) Temperature	19.4 - 26.7 °C (67 - 80 °F) Steady State Controllability: ±0.56 °C (1 °F)
Indoor (Return) Humidity	13.9 - 23.9 °C Wet Bulb (57 - 75 °F) Steady State Controllability ±0.4 °C (0.72 °F)
Indoor (Supply) Airflow Measurement	1,699 - 33,980 SCMH (1,000 - 20,000 SCFM)
Test Unit Capacity	Up to 176 kW (50 Tons)

EROSION CORROSION LAB

ITEM	**Internal Erosion-Corrosion Cycle** (2 Rigs)
Fluids	Standard depleted coolant (30% Modine MC-2002 / 70% ASTM D1384 corrosive water) ASTM D-1384 corrosive water (per GE0108) OY water ASTM D1193-91 Type IV deionized water
Flow Rate	Max 100 GPM (dependent upon test article characteristics)
Frequency	Constant Flow
Temperature	Max 121 °C (210 °F)
Capacity	Up to 2 test articles (Rig #8) Up to 6 test articles (Rig #9)

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