



Rutting Evaluation and NJDOT's Approval Process for WMA in New Jersey

May 14th, 2009

Advanced Technology and
Manufacturing Center

University of Massachusetts, Dartmouth



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NJDOT Concerned with Rutting Susceptibility

- With decreased mixing temperatures, NJDOT concerned of rutting potential
 - ◆ Reduction in age hardening
 - ◆ NJDOT not interested in paying for a PG76-22 that does not provide "PG76-22 performance"
- Aging Index, proposed by AAT on NCHRP 9-43 Project, recommends mixing temperature reduction limits based on binder
 - ◆ Can this be related to mixture testing?
 - ◆ Different plant conditions/RAP



Aging Ratio

Based on the stiffening that occurs during the mixing/production of the HMA – simulated in laboratory using RTFO Aging

$$\text{Aging Ratio} = \frac{G_{\text{RTFO}}^*}{G_{\text{Orig}}^*}$$

PG High Temperature Grade	Aging Index											
	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6
	Minimum WMA Mixing Temperature Not Requiring PG Grade Increase, °F											
52	215	215	215	215	215	215	220	220	225	225	230	230
58	215	215	215	220	225	230	235	235	240	240	245	245
64	215	215	220	230	235	235	240	245	245	250	250	250
67	215	220	230	235	240	245	250	255	255	255	260	260
70	215	220	230	240	245	245	250	255	255	260	260	260
76	215	225	235	245	250	255	260	260	265	265	265	270
82	215	235	245	250	255	260	265	265	270	270	275	275





Laboratory Produced Mixes

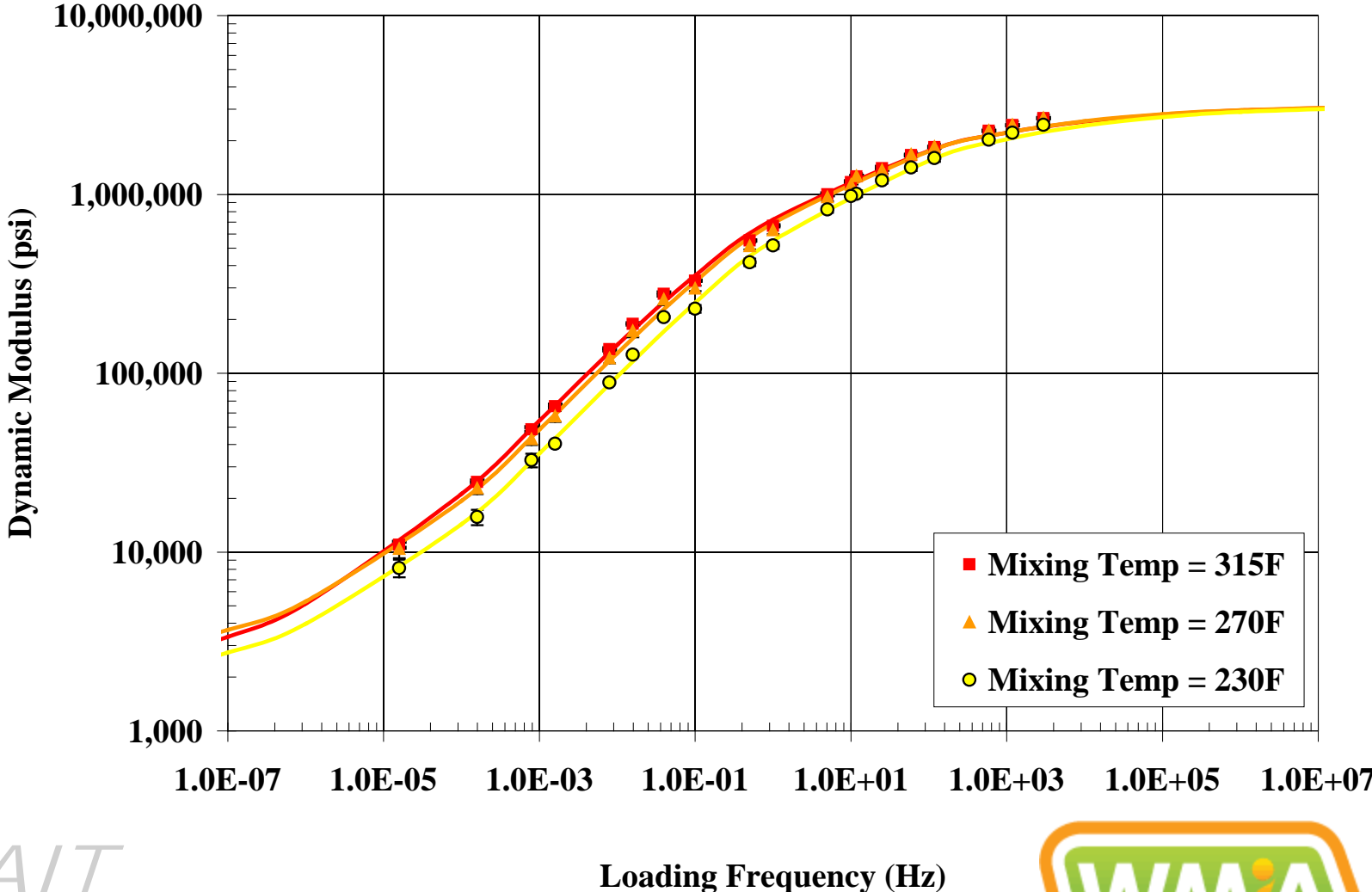
Dynamic Modulus Test
(Measuring Mixture Stiffness)



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76-22 (No WMA)

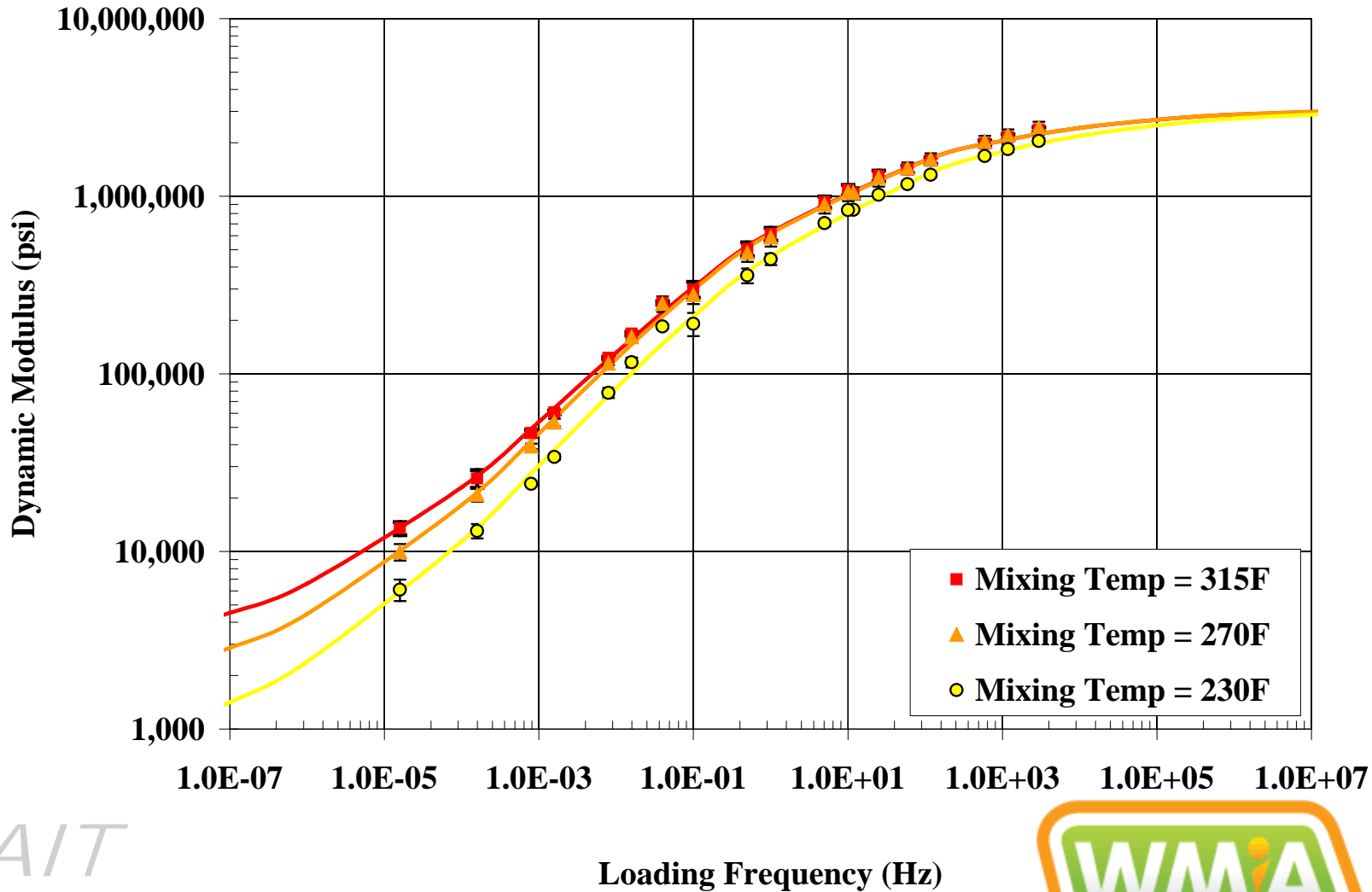


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Loading Frequency (Hz)



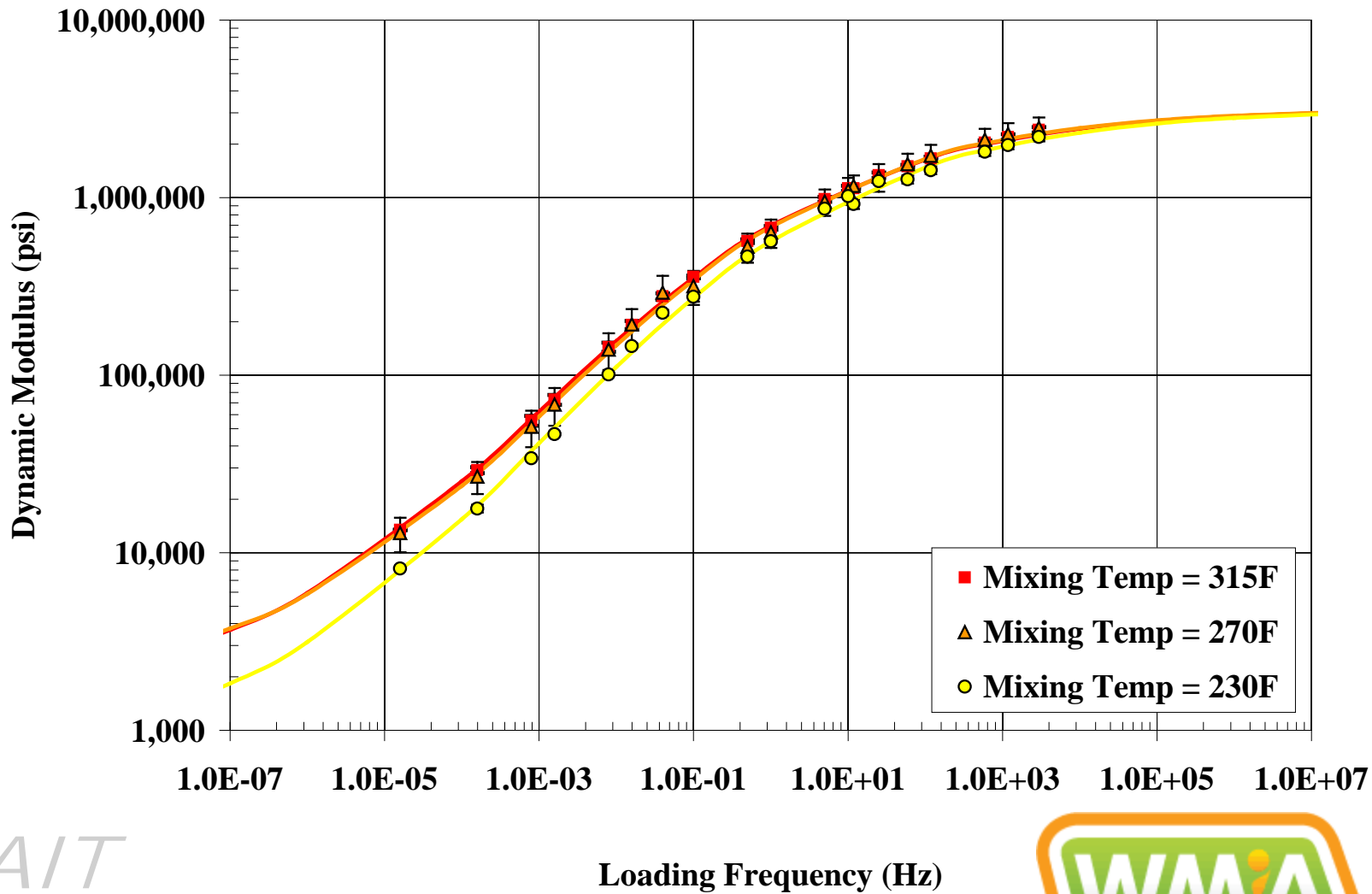
0.5% Sasobit



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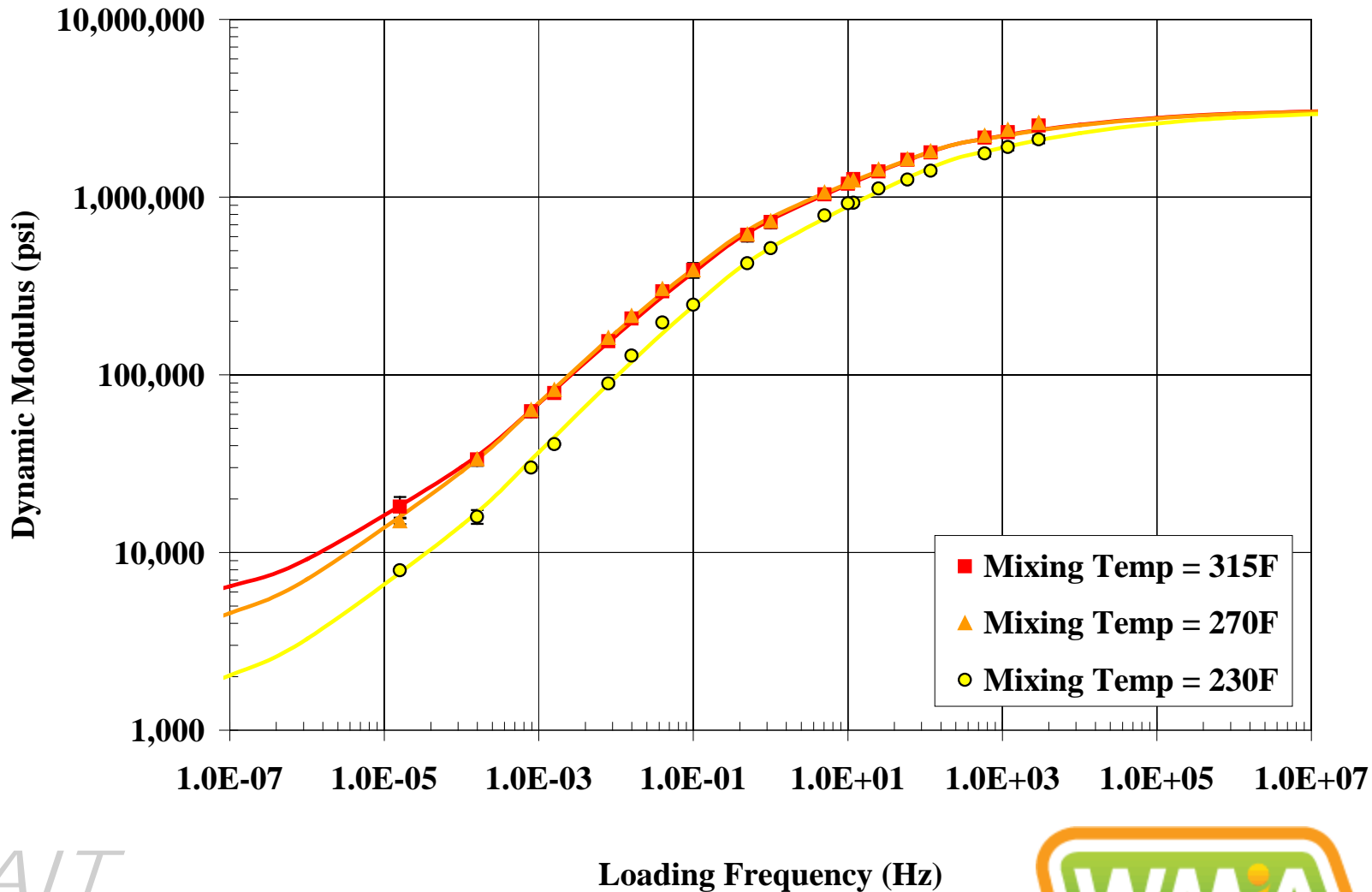
1.0% Sasobit



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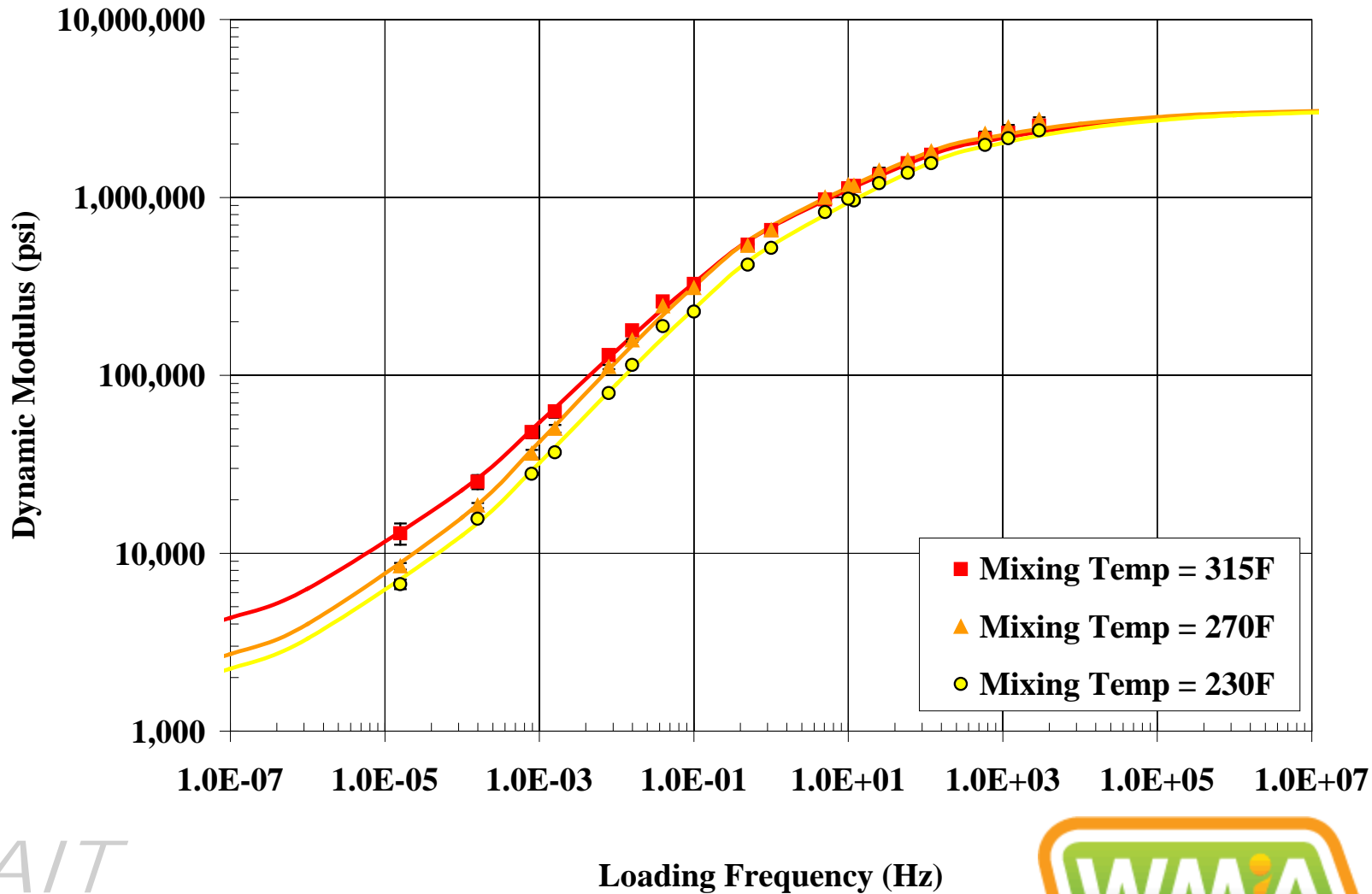
1.5% Sasobit



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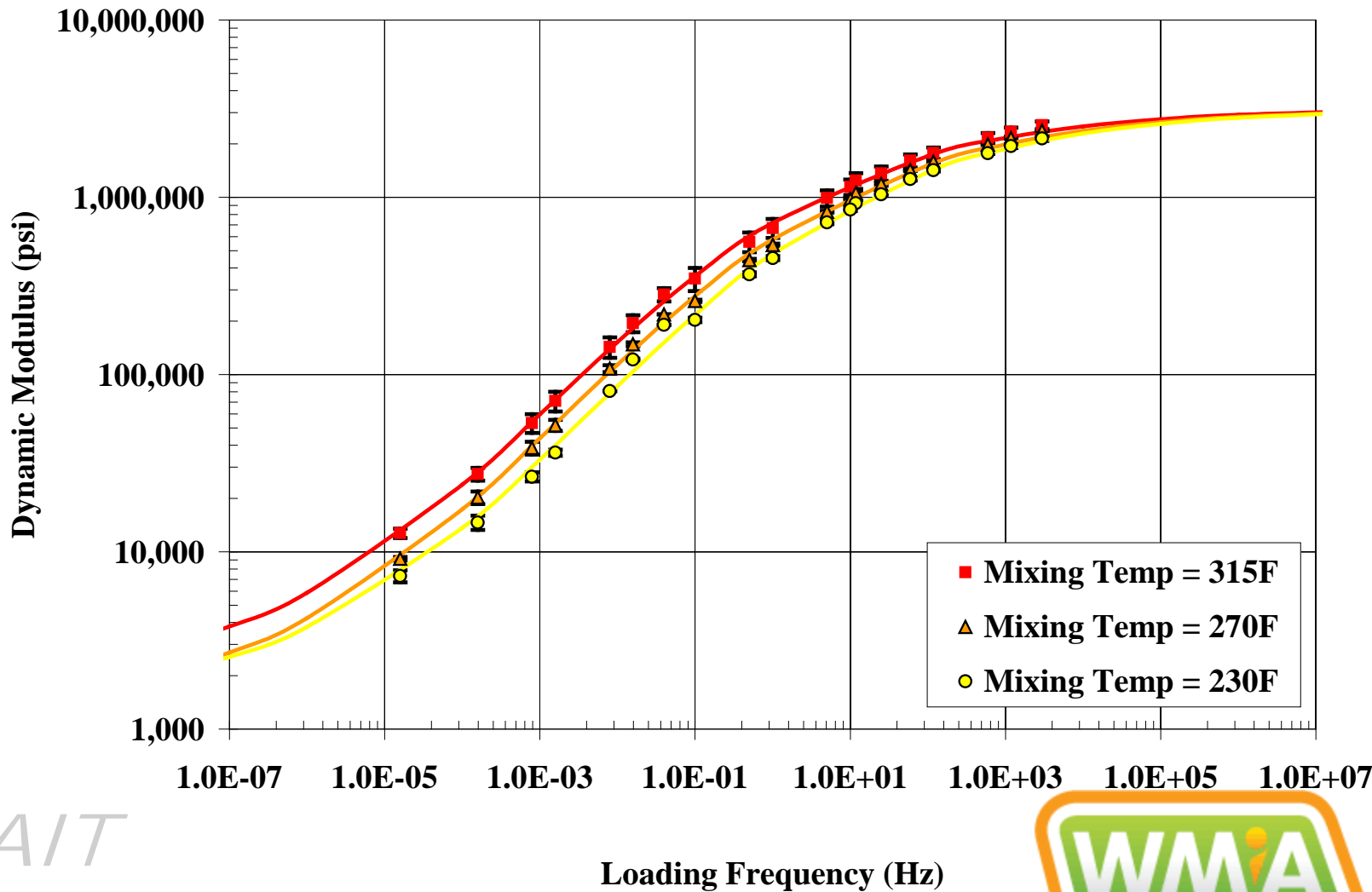
1.0% Rediset



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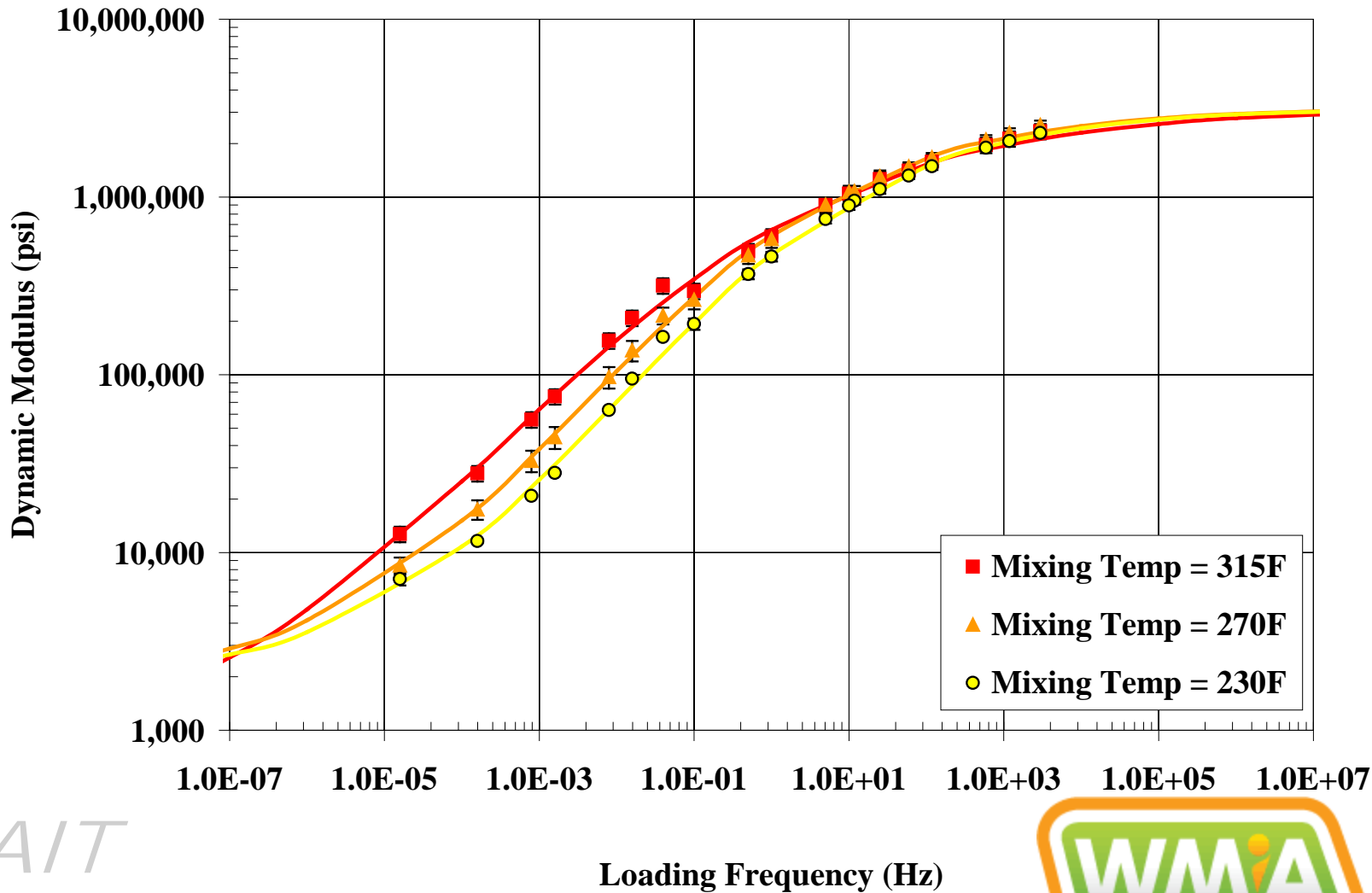
2.0% Rediset



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0.6% REVIX (3G)

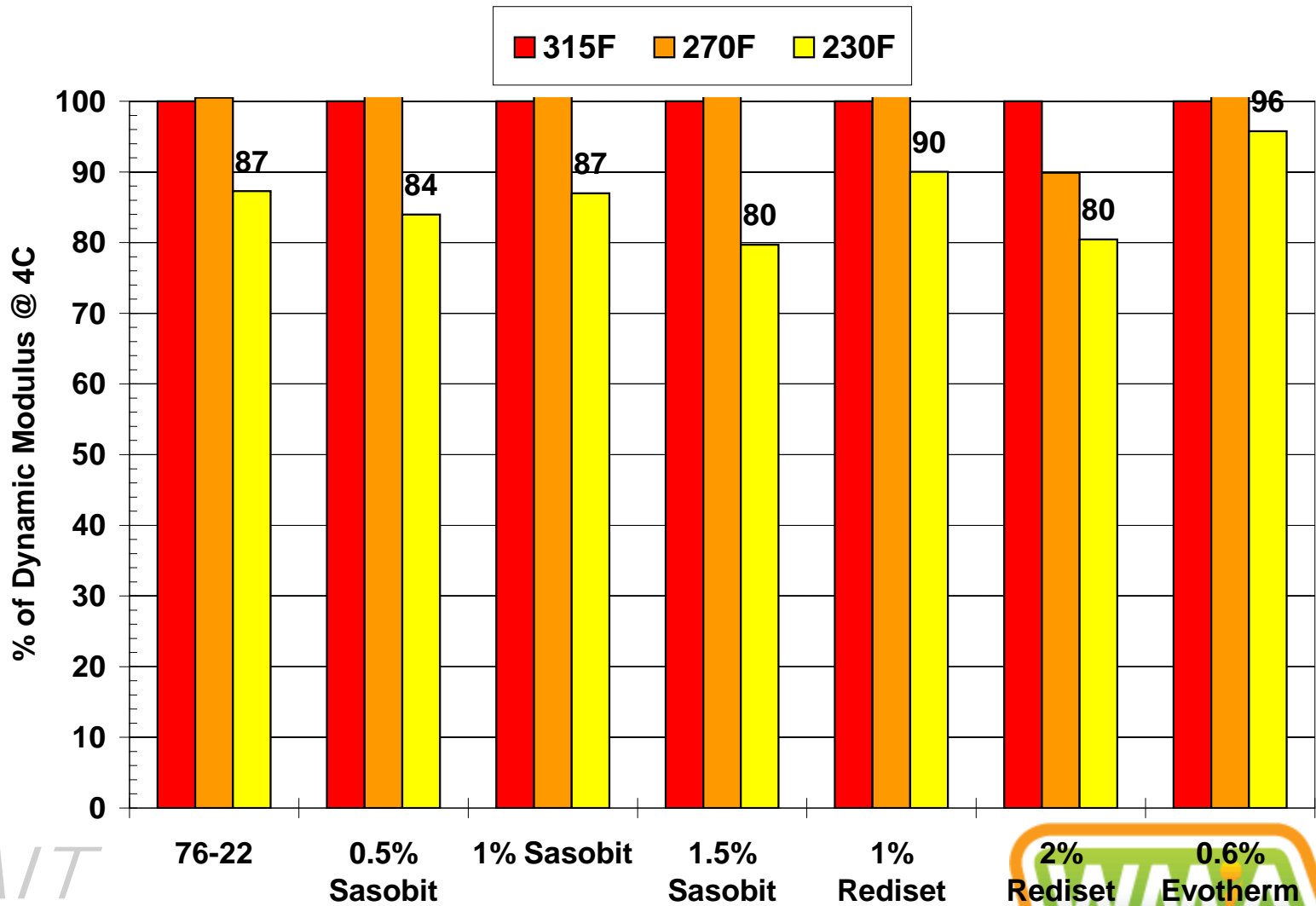


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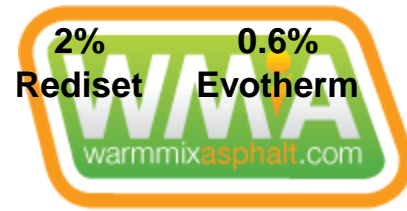


Loading Frequency (Hz)

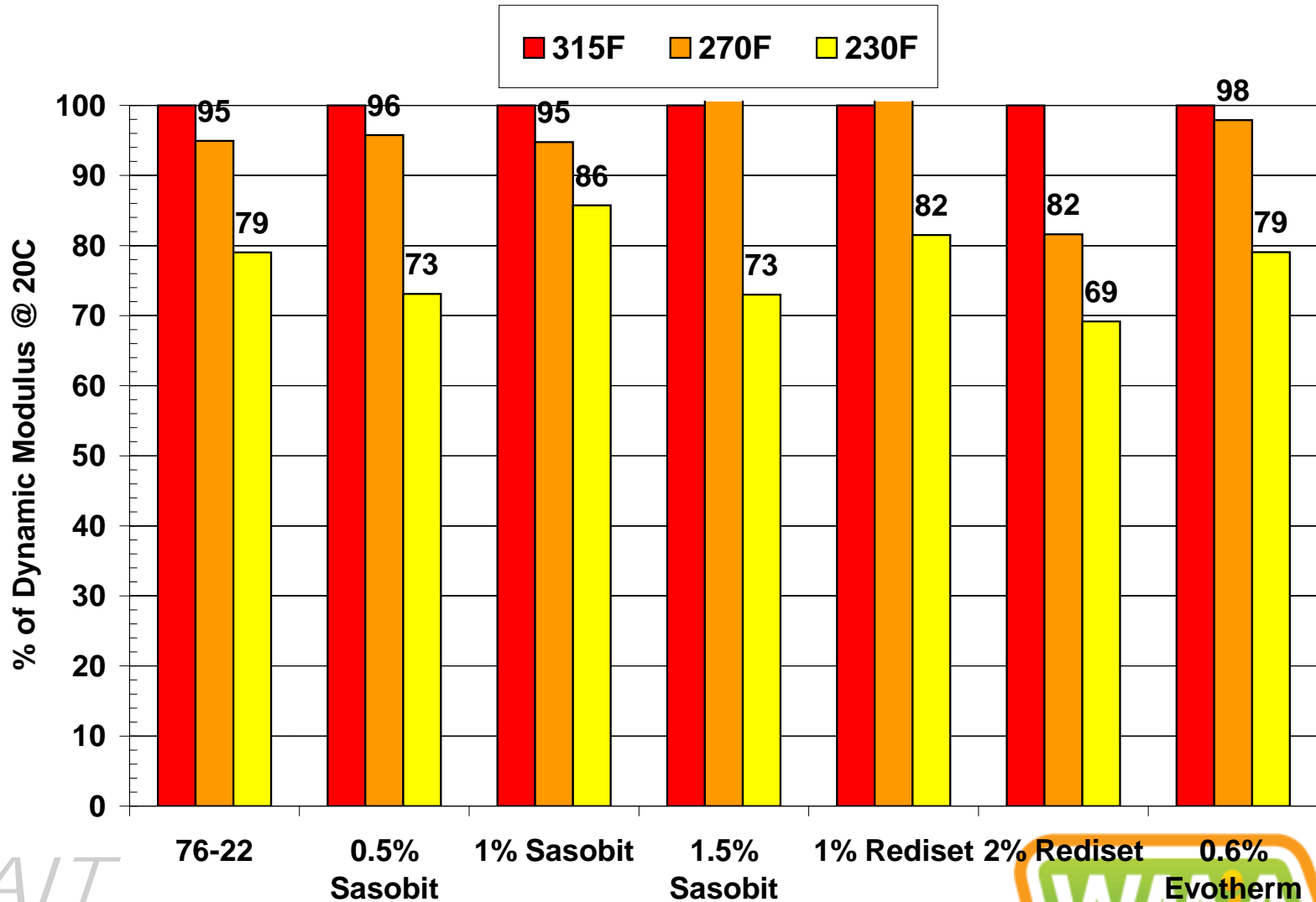
Average Dynamic Modulus at 4°C



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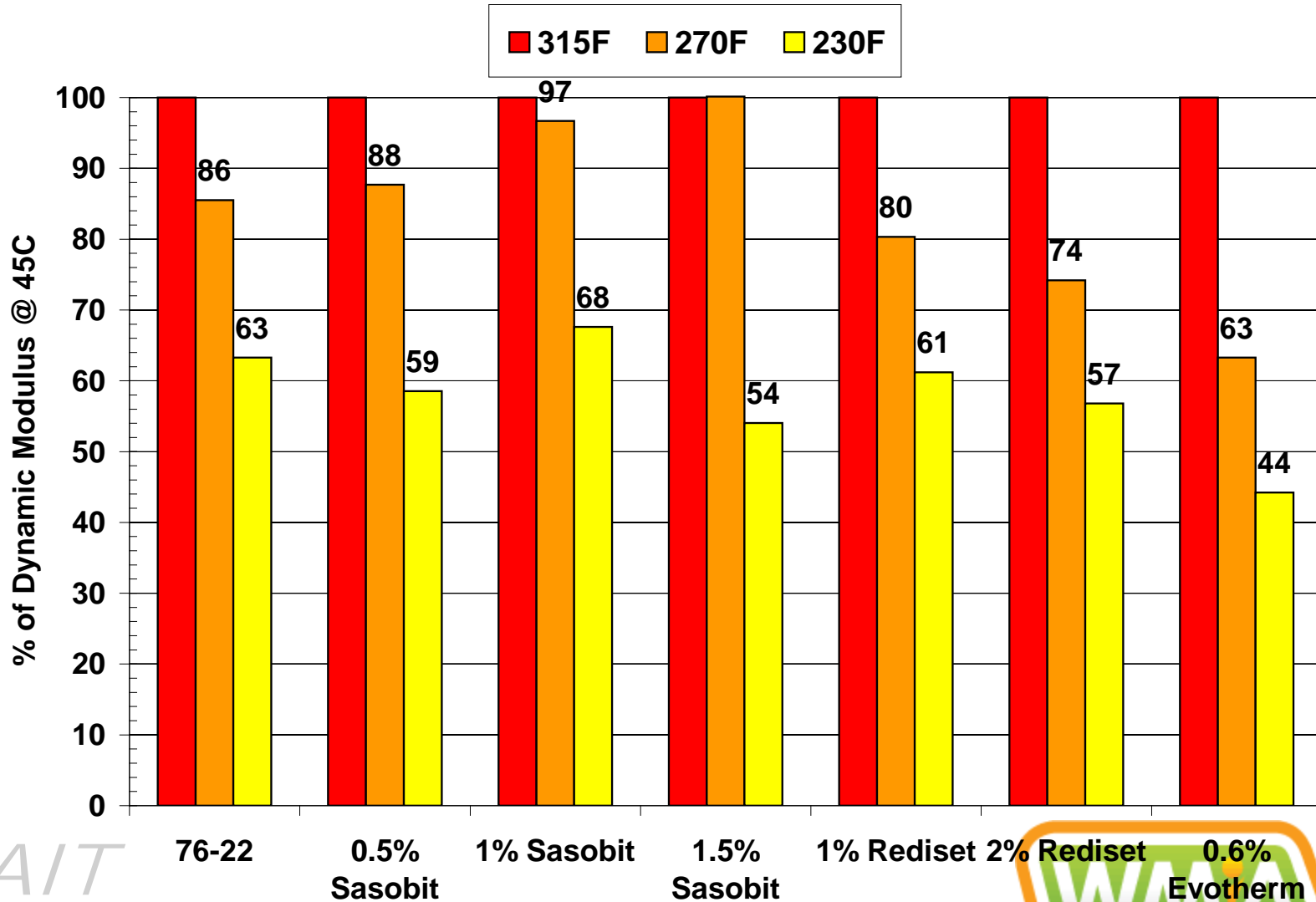
Average Dynamic Modulus at 20°C



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Average Dynamic Modulus at 45°C



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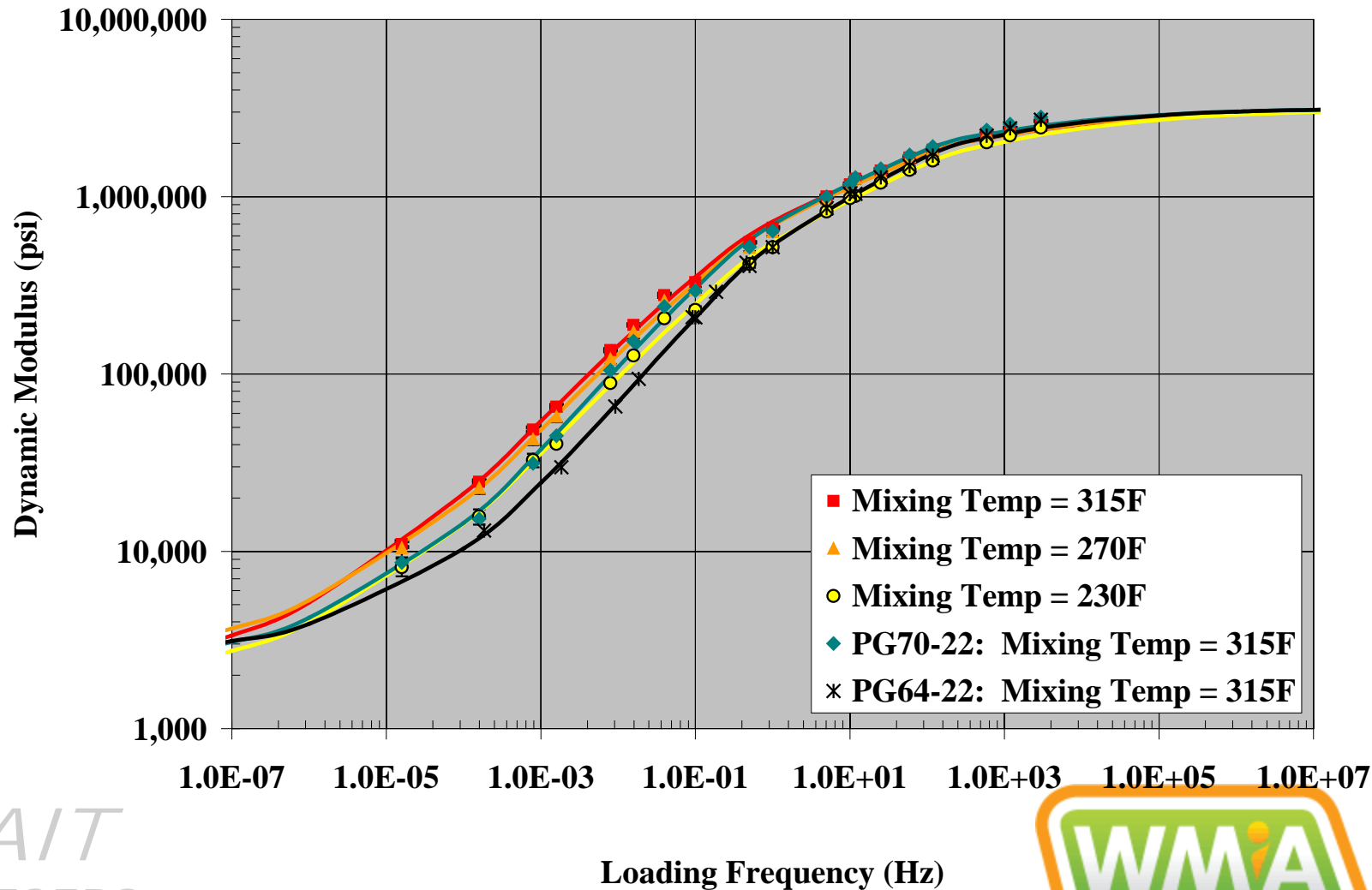


Summary of Dynamic Modulus Data

- Mixture stiffness is reduced as mixing/compaction temperatures decrease, but not evenly
- On average:
 - ◆ 4°C Test Temperature
 - No stiffness reduction found at 270F mixing temp
 - 14% reduction in stiffness at 230F mixing temp
 - ◆ 20°C Test Temperature
 - 5% reduction found at 270F mixing temp
 - 23% reduction found at 230F mixing temp
 - ◆ 45°C Test Temperature (Rutting Conditions)
 - 16% reduction found at 270F mixing temp
 - 42% reduction found at 230F mixing temp



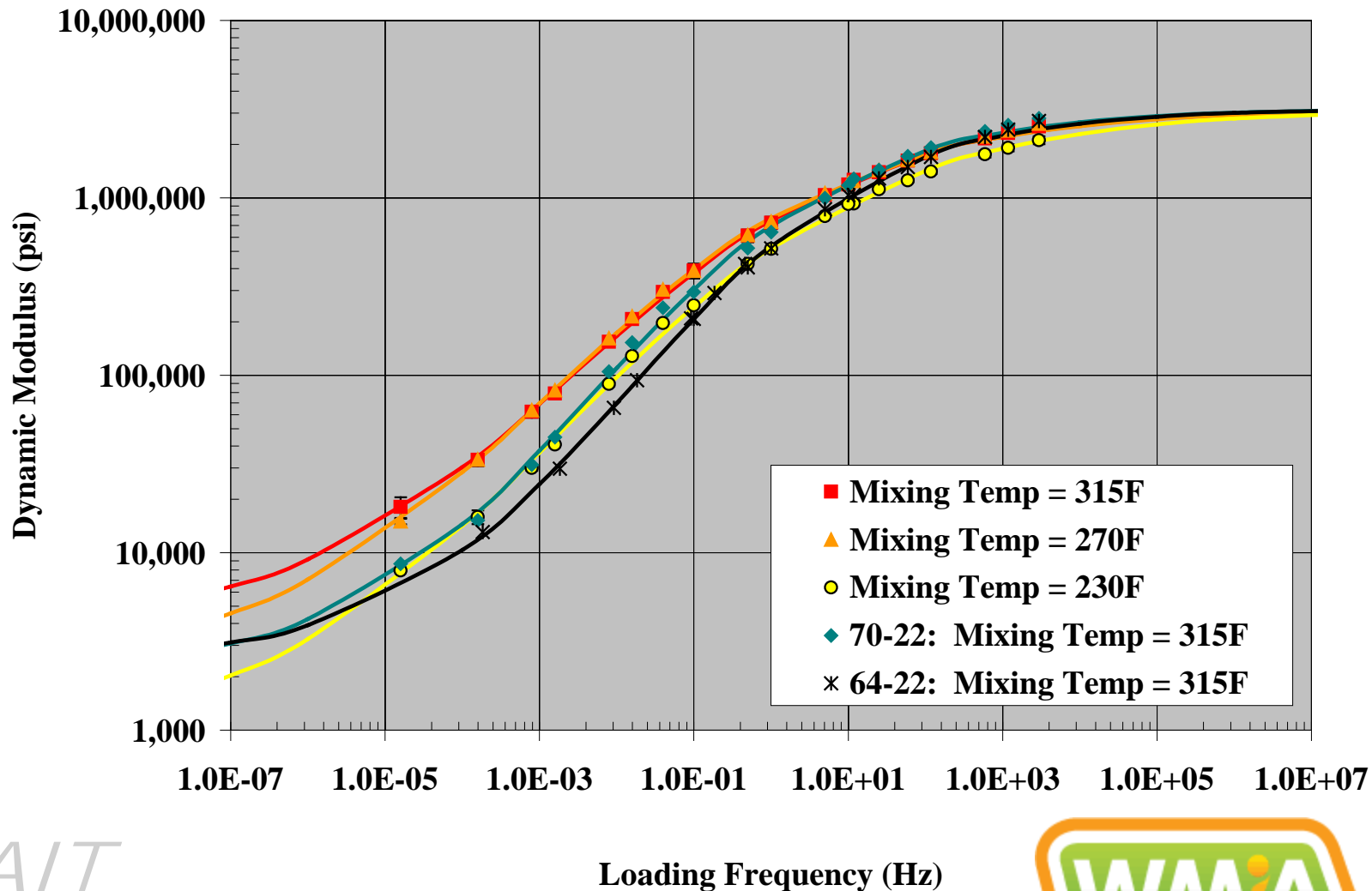
PG76-22 with Softer Binders



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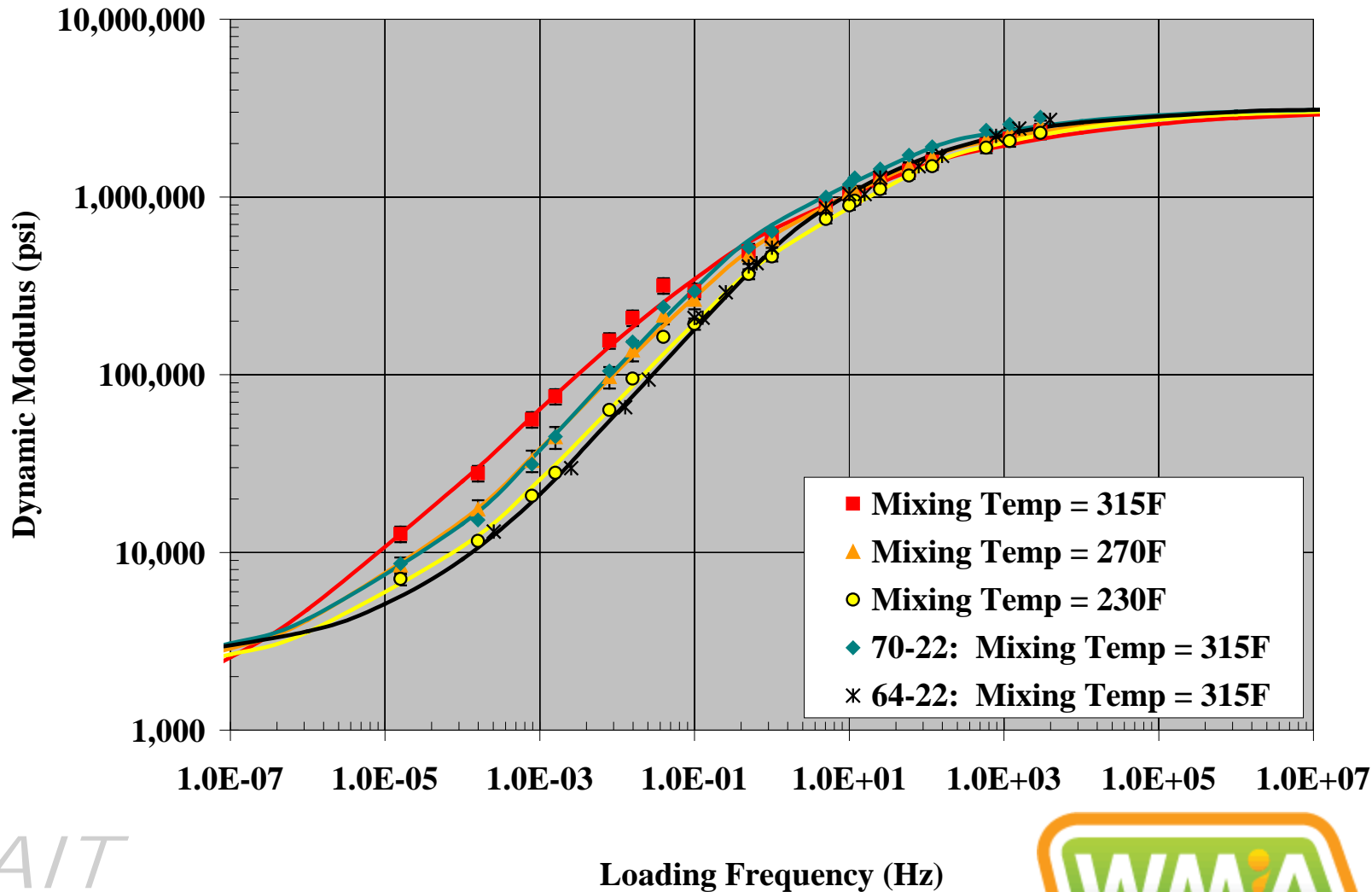
1.5% Sasobit with Softer Binders



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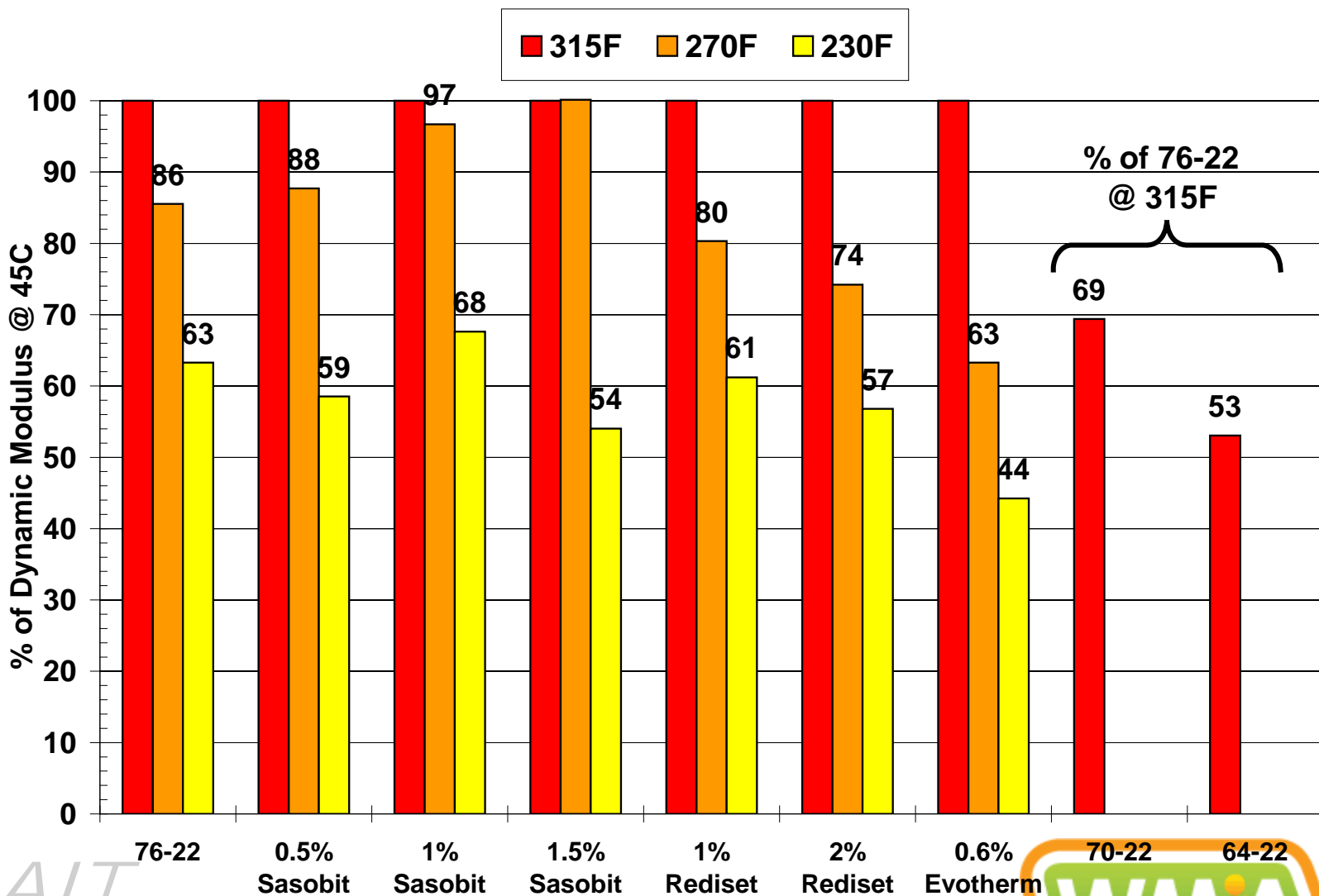
0.6% REVIX with Softer Binders



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Dynamic Modulus at 45°C



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Summary of Dynamic Modulus Data

- Testing softer binders (PG70-22 and PG64-22) indicated that:
 - ◆ 30 to 35% reduction in dynamic modulus at 45°C equivalent to dropping from PG76 to PG70-22
 - ◆ 45 to 50% reduction in dynamic modulus at 45°C equivalent to dropping from PG76 to PG64-22
- NJDOT potentially using E^* as “Pass/Fail” for accepting plant produced WMA
 - ◆ “To limit potential for PG grade reduction, no technology should allow for E^* reductions greater than 20% from baseline mix”





Plant Produced Data for Dynamic Modulus



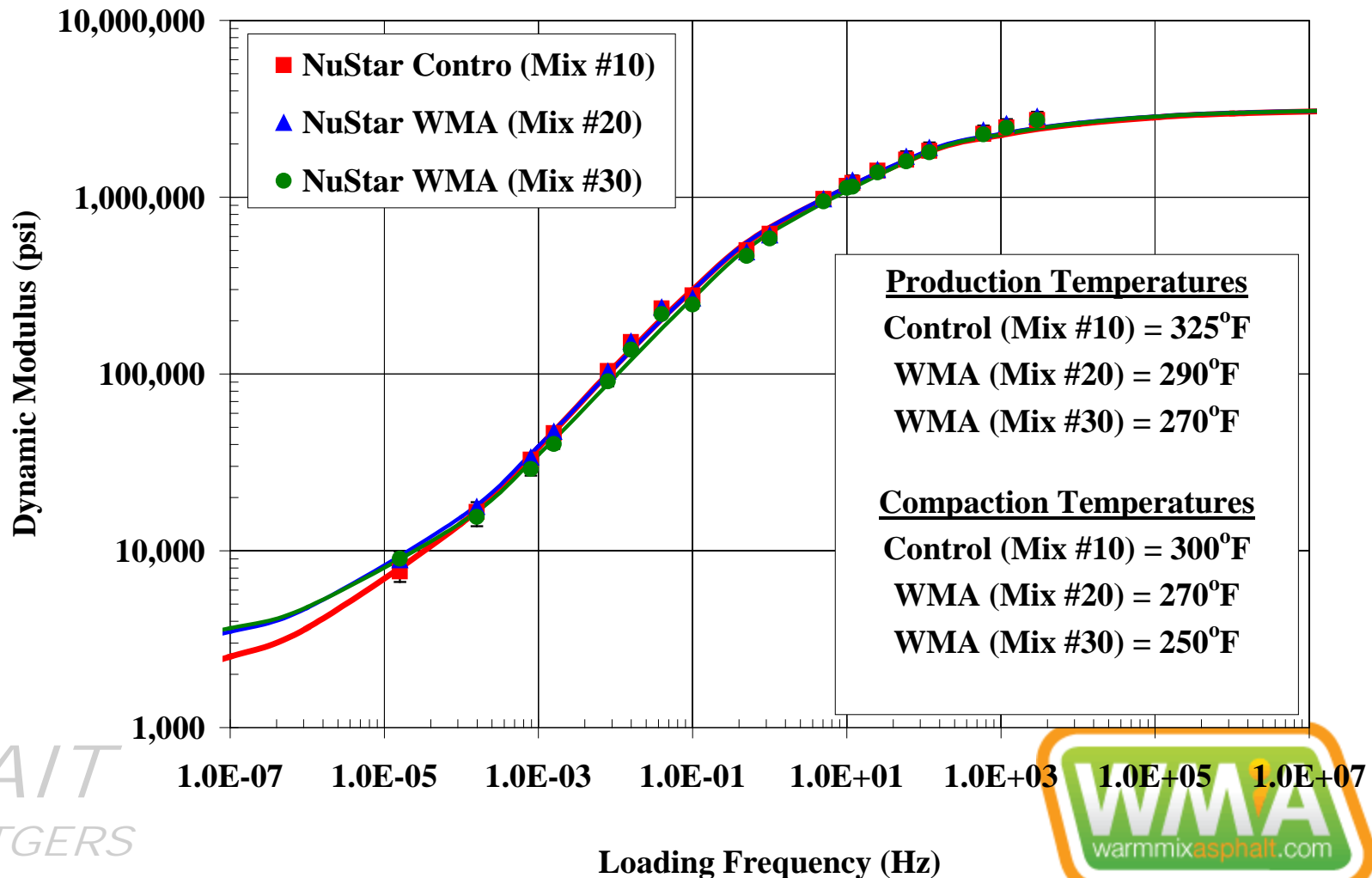
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Dynamic Modulus – NJ I78 NuStar 3G (REVIX)

325F to 270F = 10% Decrease in Average E^* @ 45C

Conditioned for 2 hrs at Compaction Temperature

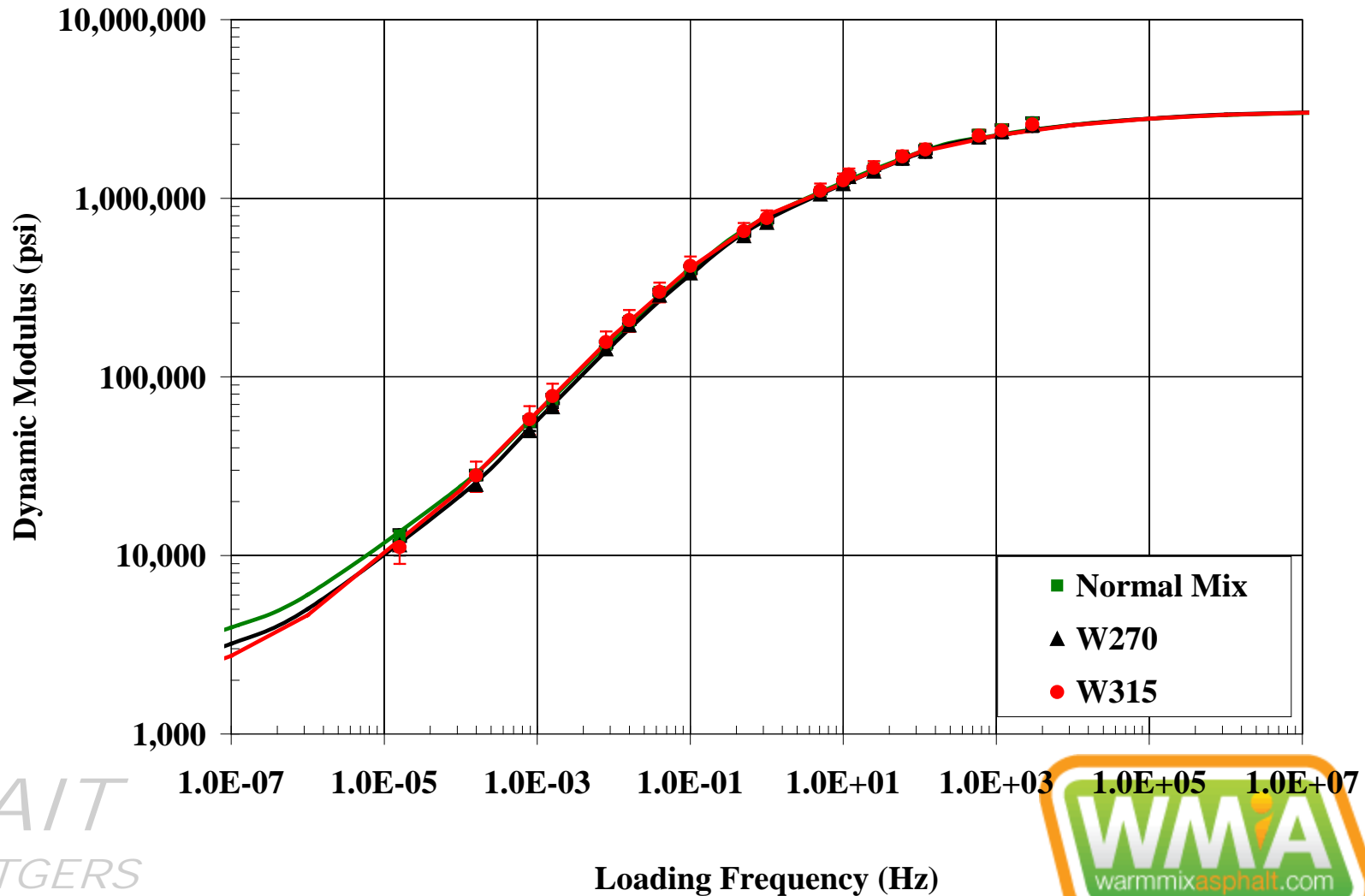


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Dynamic Modulus – NJ Rt 38 Sasobit

315F to 270F = 7% Decrease in Average E^* @ 45C



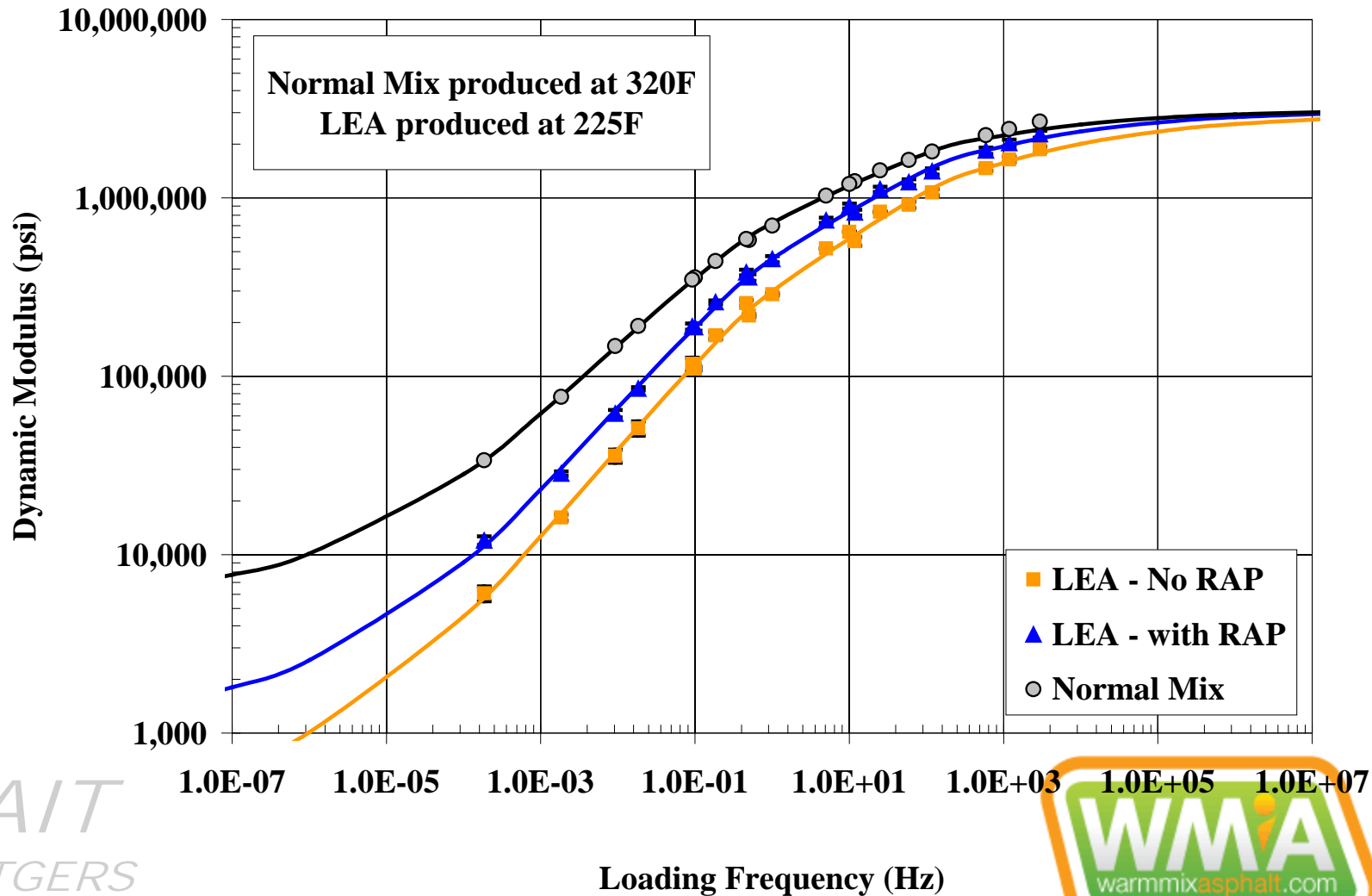
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Loading Frequency (Hz)

Dynamic Modulus – NYSDOT LEA

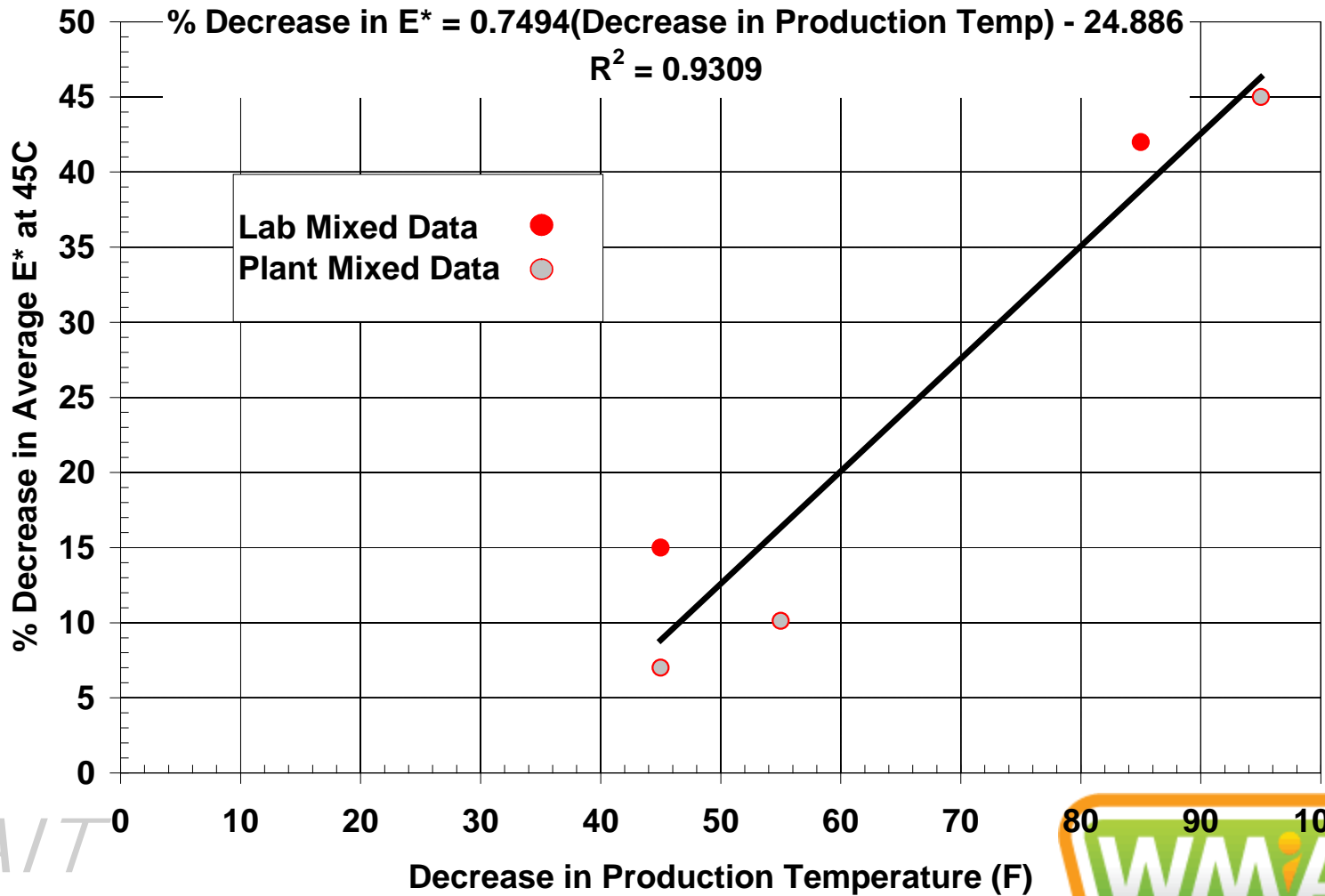
320F to 225F = 45% Decrease in Average E^* @ 45C



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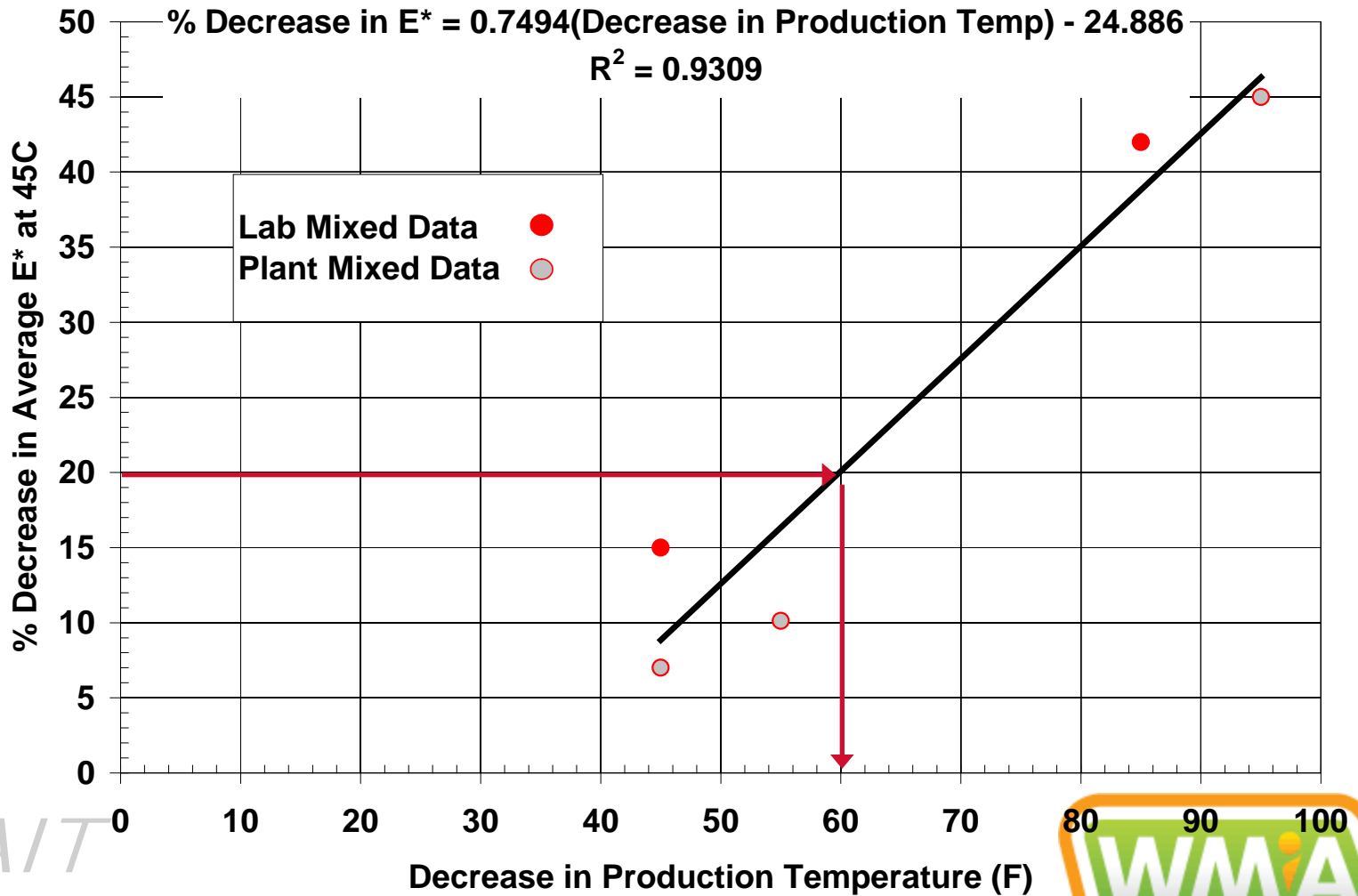
% Decrease in Stiffness vs Decrease in Production Temp



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% Decrease in Stiffness vs Decrease in Production Temp



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Limiting Production Temperature

- From E^* testing, limiting stiffness reduction to 20% equates to limiting temperature drop to approximately 60F
 - ◆ For example, typical production temperatures equals 315F
 - ◆ Minimum production temperature = 255F





Laboratory Data

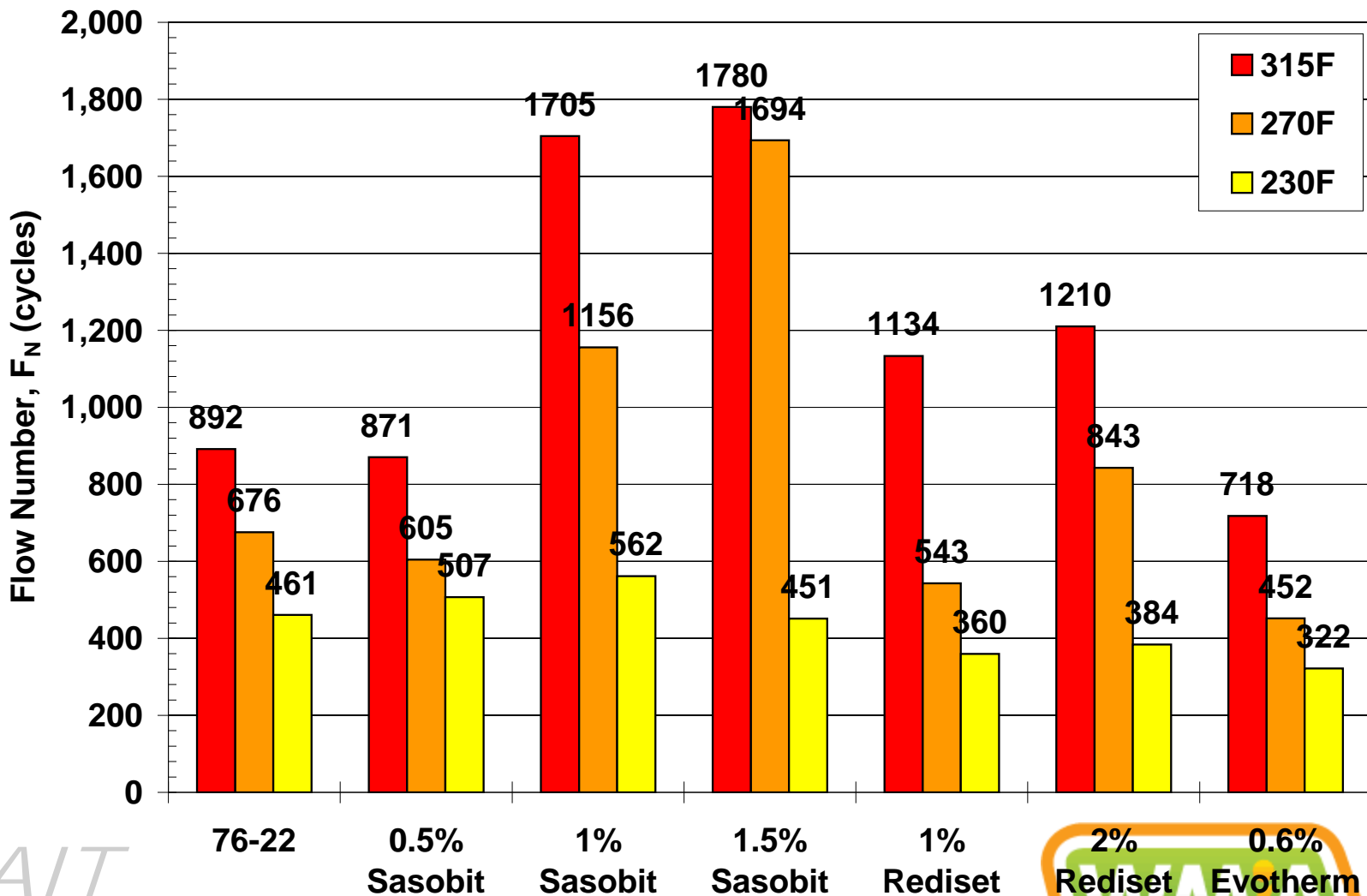
Repeated Load/Flow Number
(Measuring Resistance to
Permanent Deformation)



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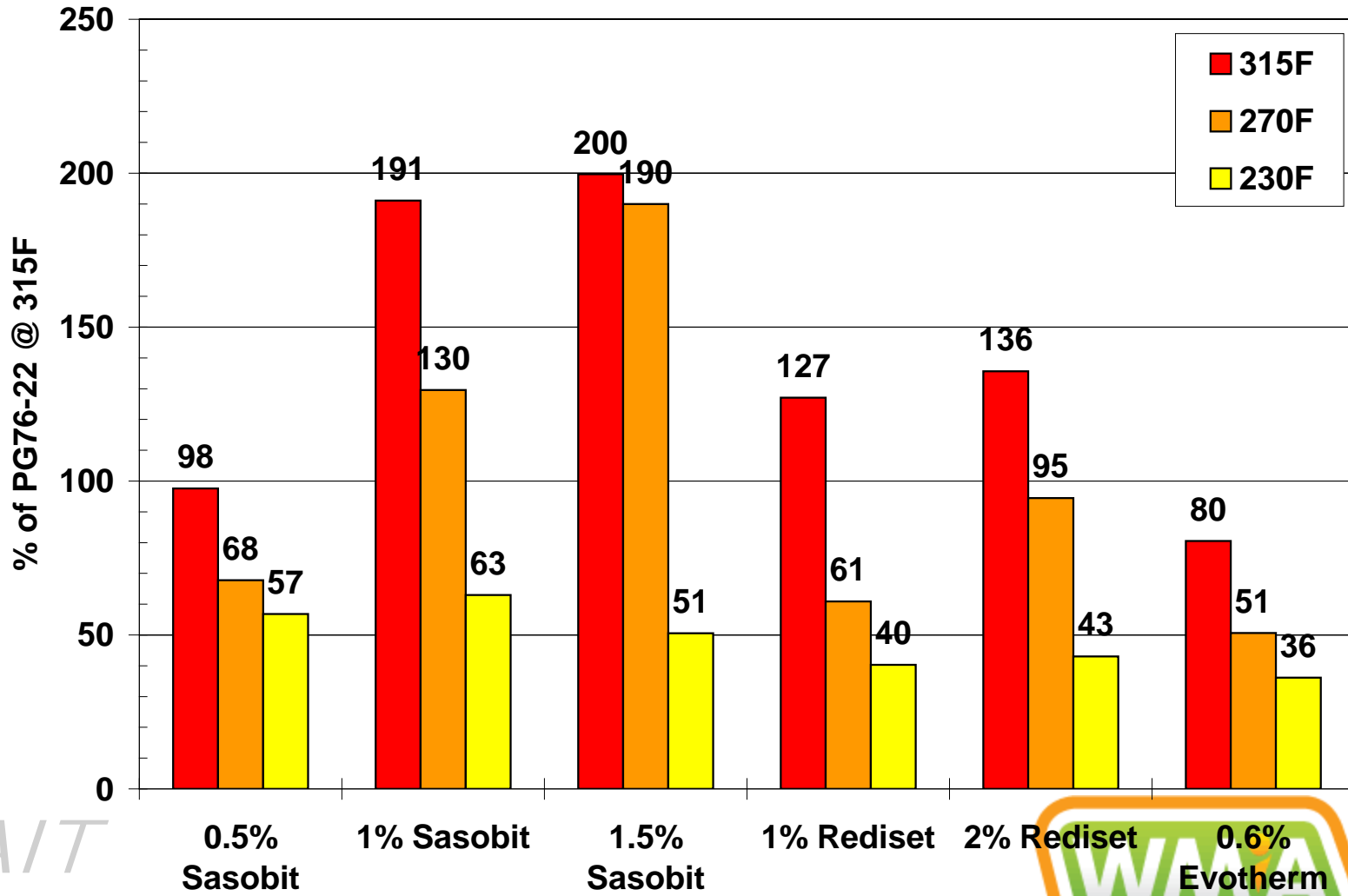
Flow Number



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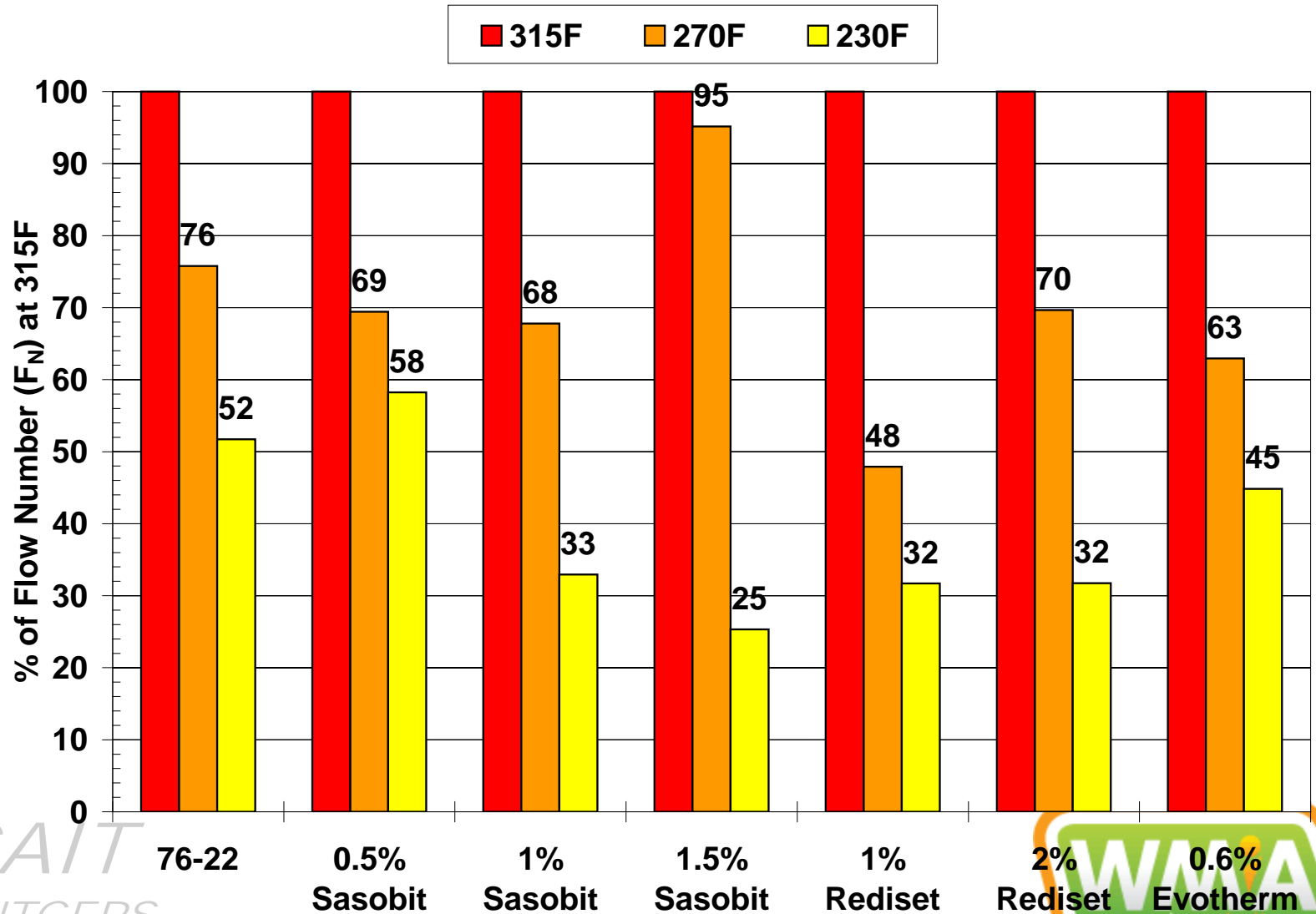
Flow Number (% of PG76-22 @ 315F)



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Flow Number (% of 315F Mixing Temp)



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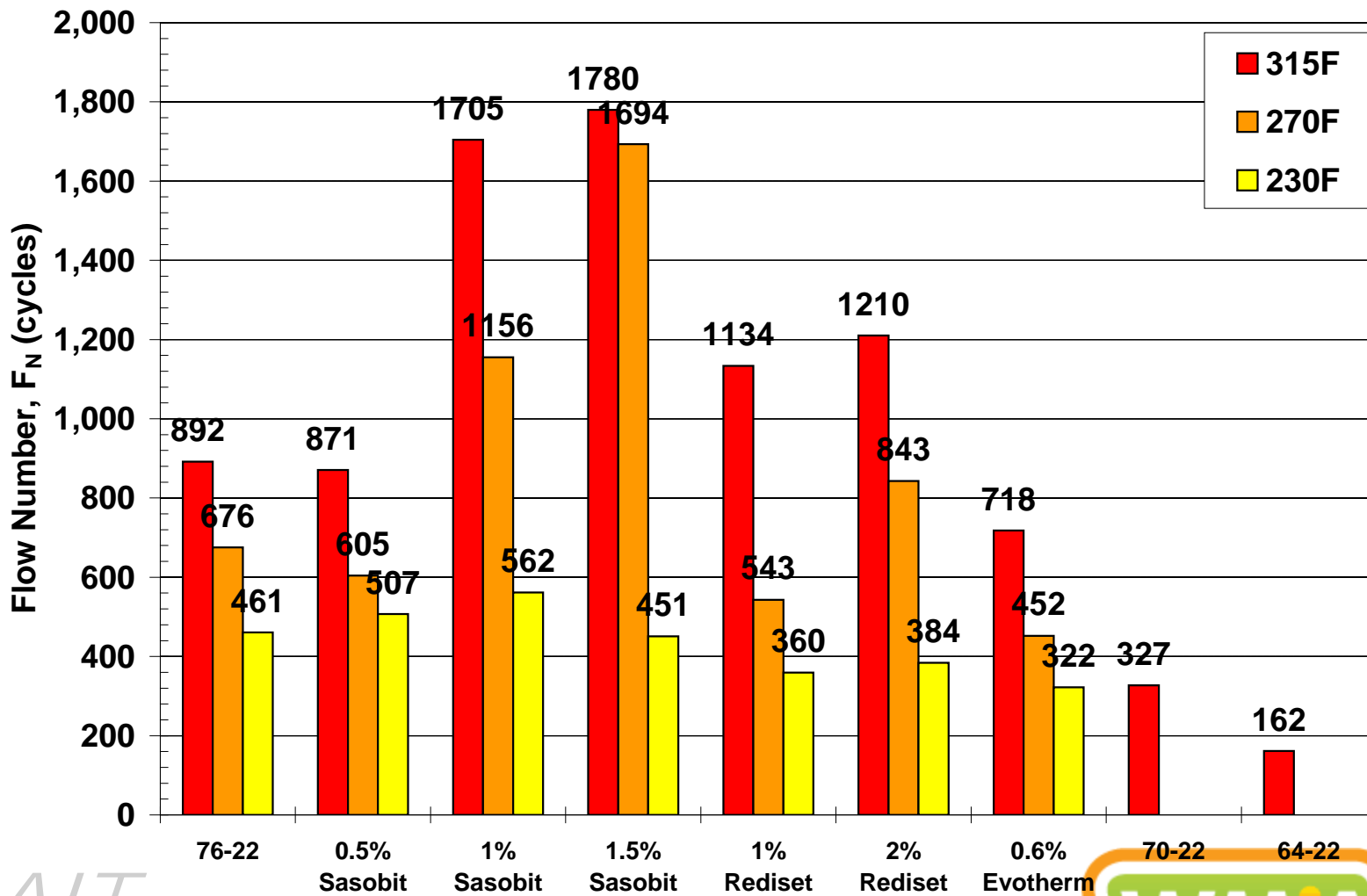


Summary of Flow Number Testing

- The resistance to permanent deformation, as measured by the Flow Number, showed to decrease with decreasing mixing/compaction temperatures
- On average:
 - ◆ A 30% decrease in the Flow Number was found when decreasing the mixing/compaction temperature from 315F to 270F
 - ◆ A 60% decrease in the Flow Number was found when decreasing the mixing/compaction temperature from 315F to 230F



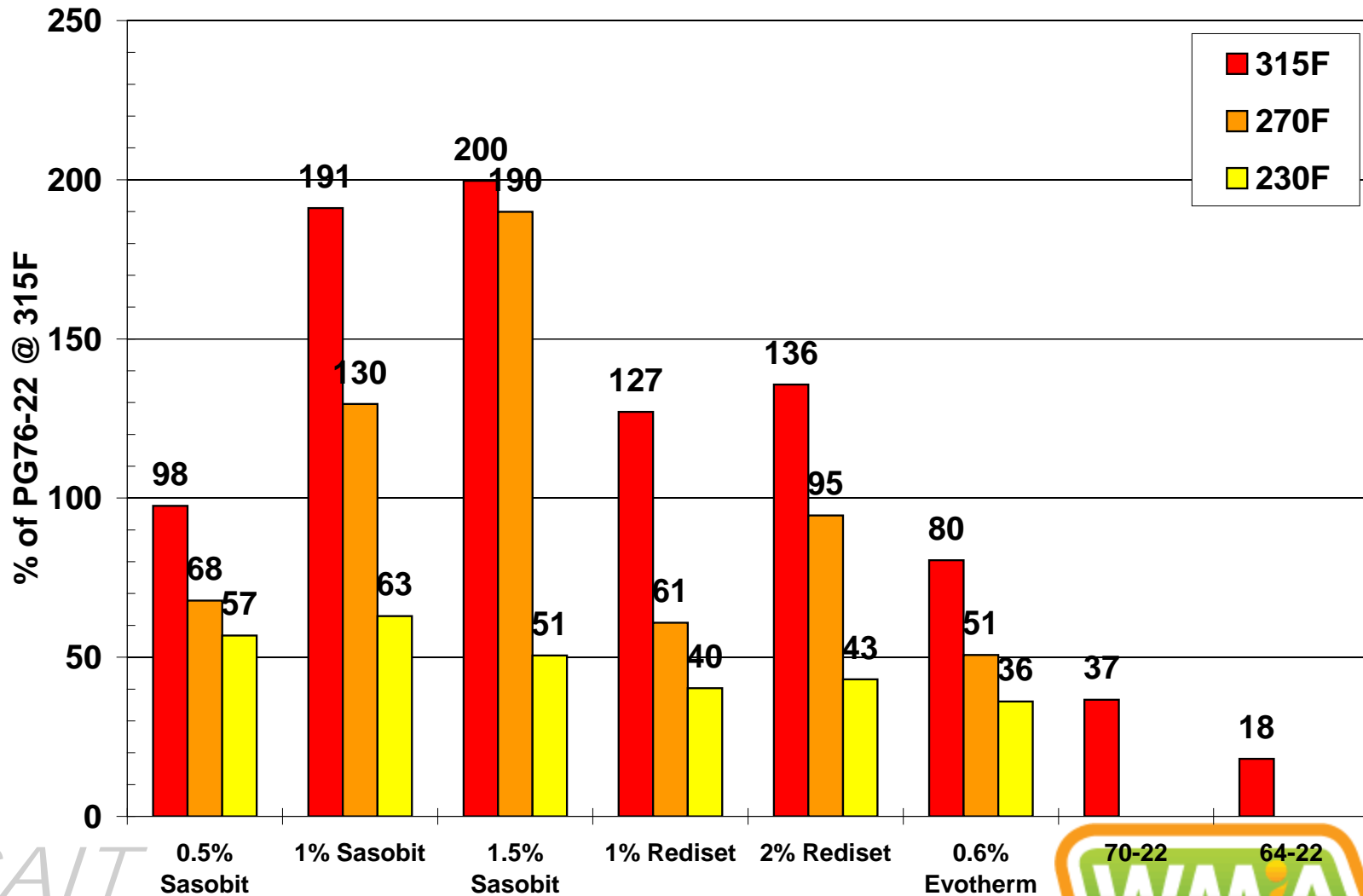
Flow Number with Softer Binders



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% of 76-22 with Softer Binders




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Summary of Flow Number Testing

- Repeated Load results showed that a 60% reduction in Flow Number equates to 1 drop in PG grade (from 76-22 to 70-22)
 - ◆ 80% reduction equates to 76-22 to a 64-22
- NJDOT comfortable using Flow Number as “Pass/Fail” for accepting plant produced WMA
 - ◆ “To limit potential for PG grade reduction, no technology should allow for Flow Number reductions greater than 30% from baseline





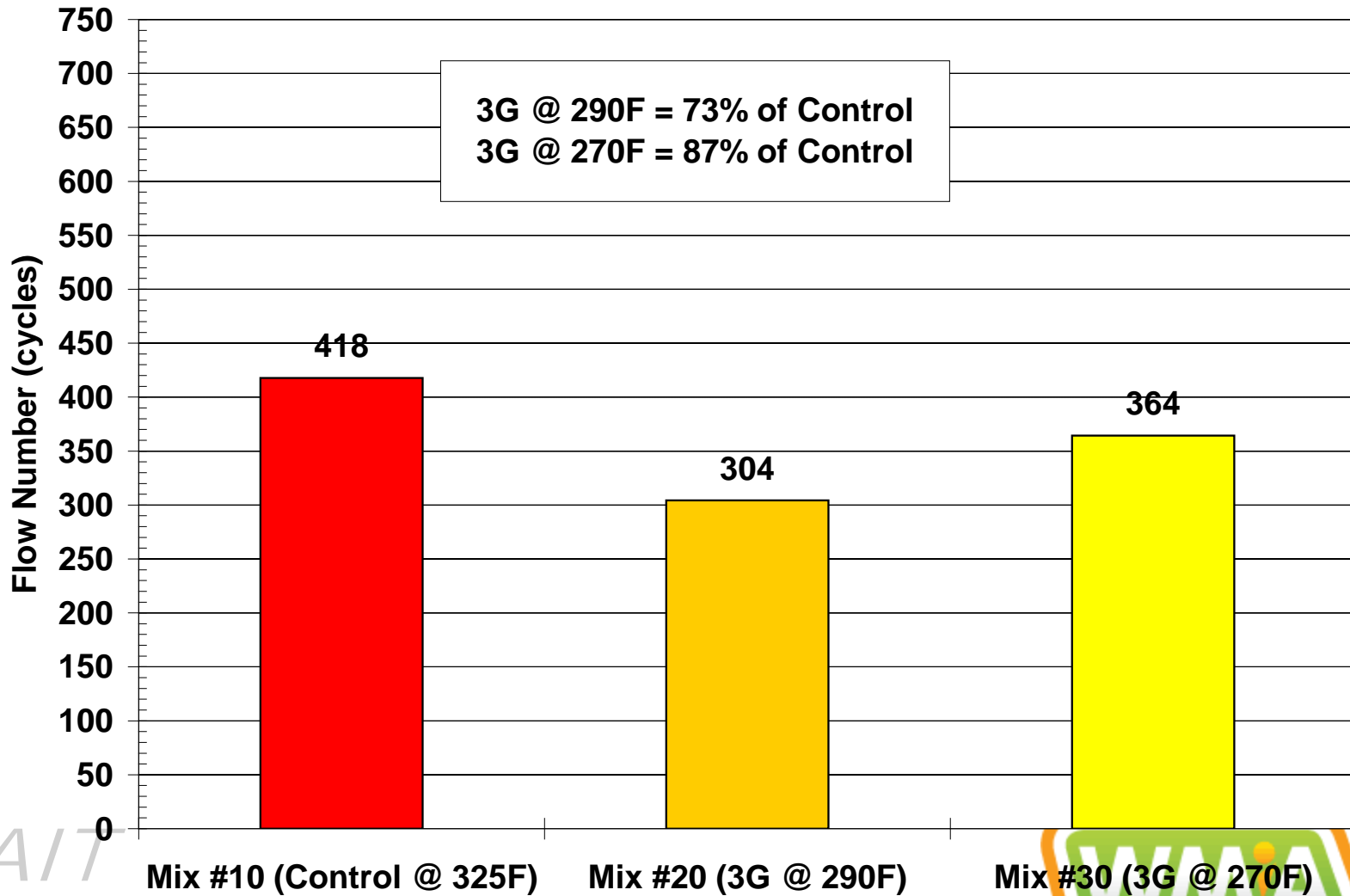
Plant Produced Data for Flow Number



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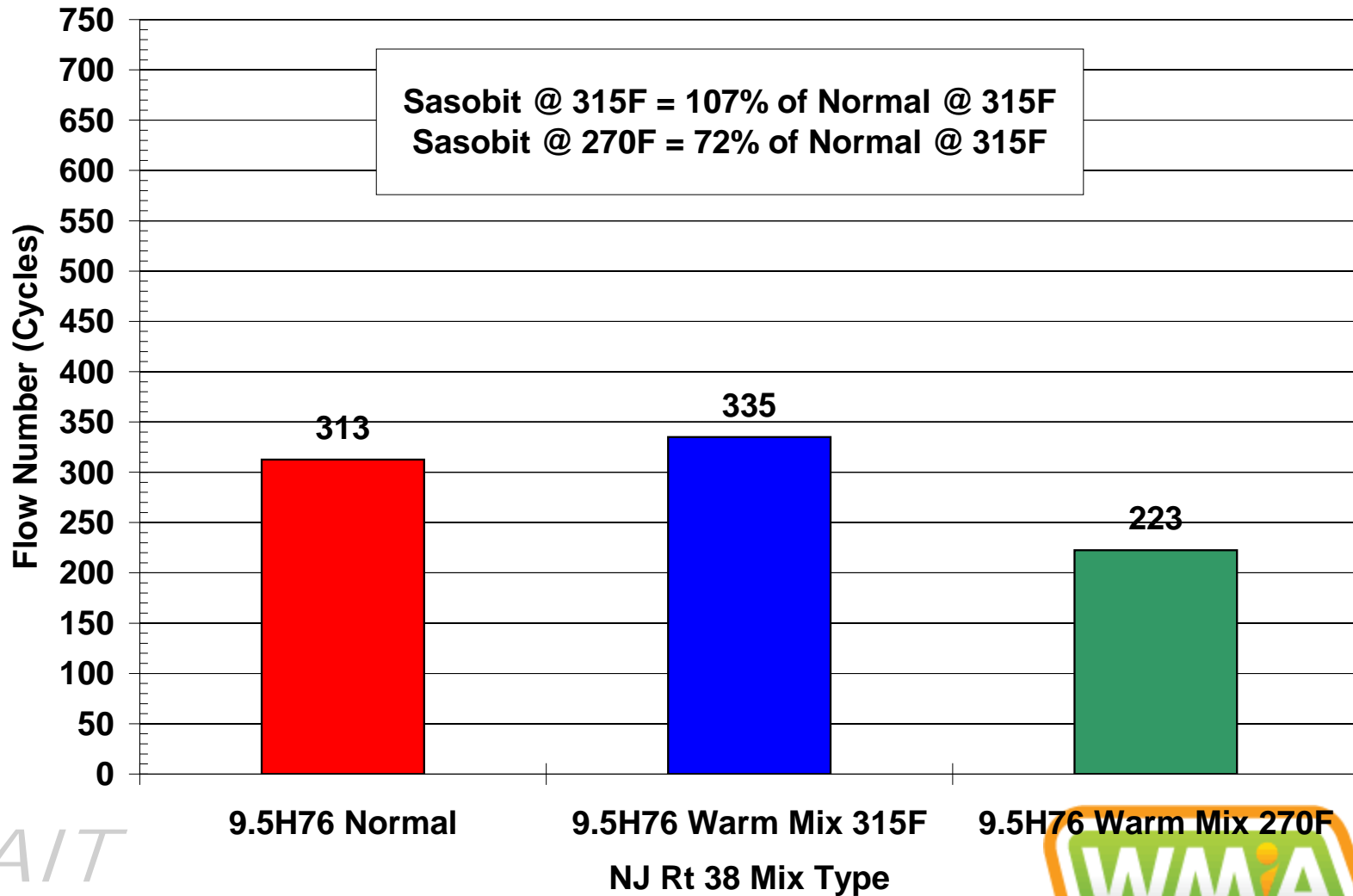
Flow Number of 3G on I78



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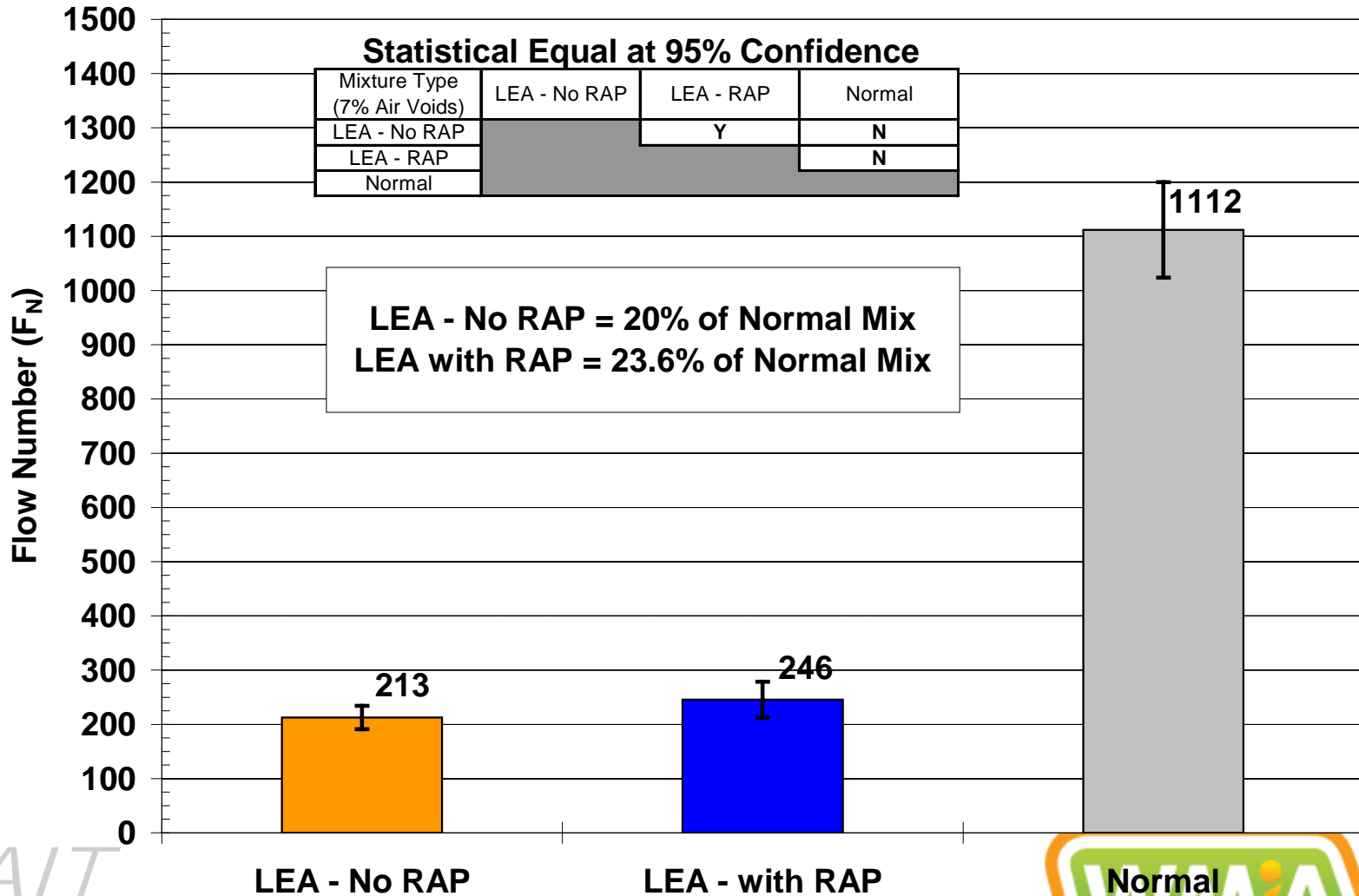
Flow Number – Rt 38 Sasobit



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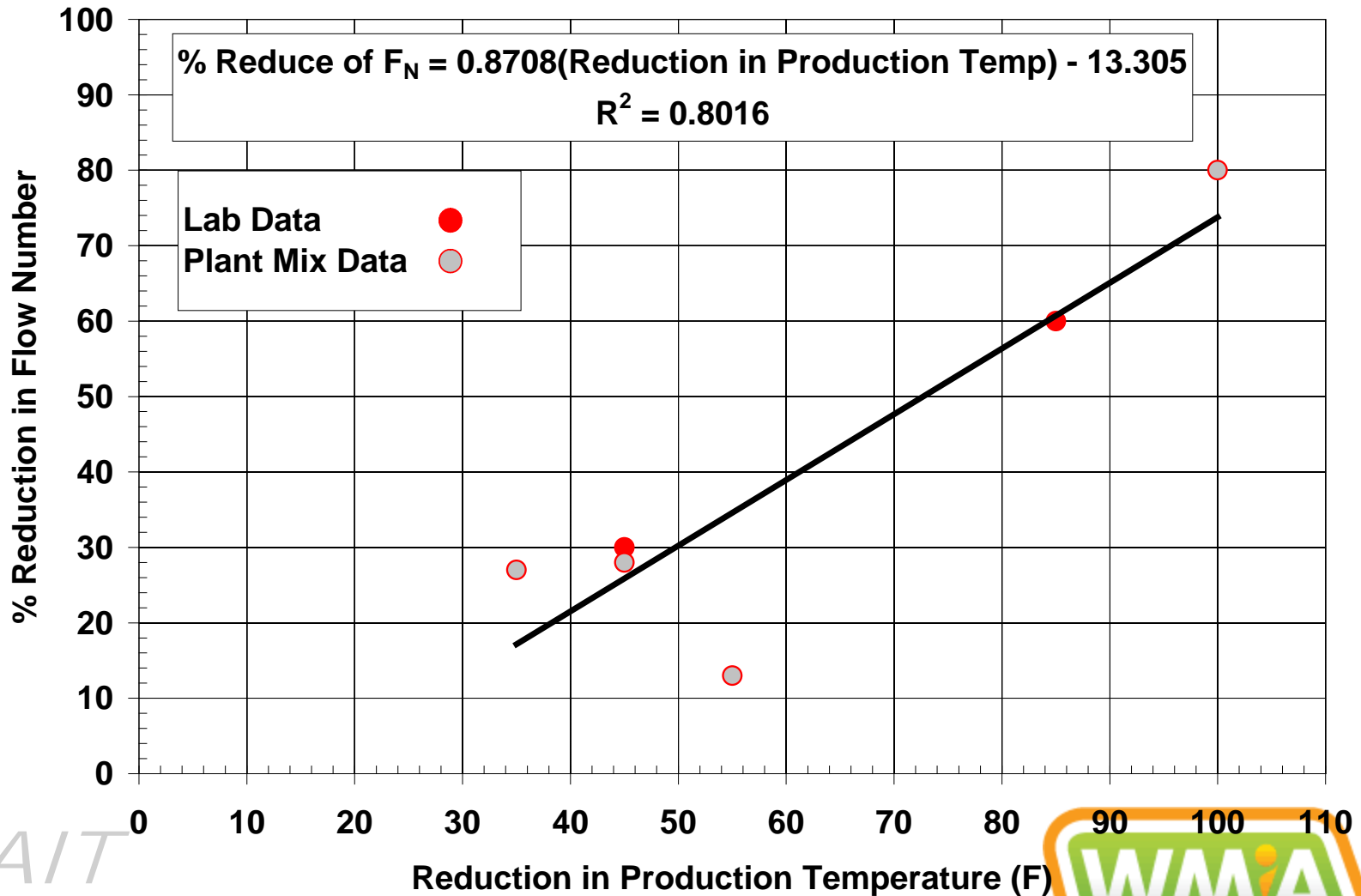
Flow Number - LEA



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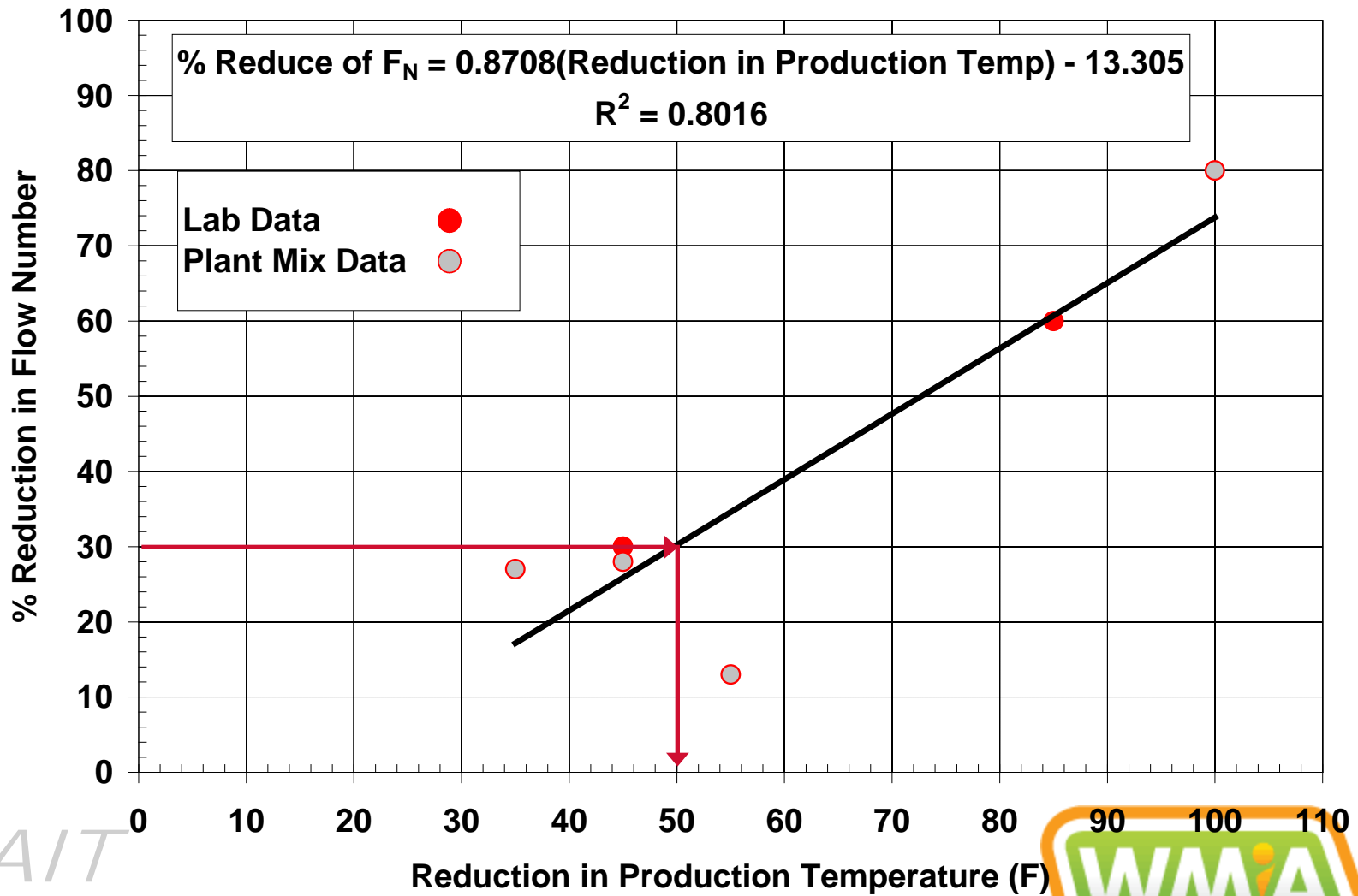
Relationship Between Reduction in Production Temp to Change in F_N



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Relationship Between Reduction in Production Temp to Change in F_N



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Limiting Production Temperature

- From Repeated Load testing, limiting Flow Number reduction to 30% equates to limiting temperature drop to approximately 50F
 - ◆ For example, typical production temperatures equals 315F
 - ◆ Minimum production temperature = 265F





Proposed NJDOT Pre-Approval Process for Warm Mix Asphalt



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Proposed Approval Process for WMA in New Jersey

- WMA additives will be allowed without performance verification when production temperatures greater than 260F
 - ◆ < 260F requires performance verification testing compared to baseline (no WMA) mix
 - Dynamic Modulus and Flow Number reductions
 - Hamburg Wheel Tracking for stripping potential
- Foaming systems need verification testing regardless of production temperature



Proposed Approval Process for WMA in New Jersey

- Each plant needs to approve “the mix”, similar to what is done today – not technologies across the board
 - ◆ i.e. 9.5H76 HMA or 9.5H76 WMA from Supplier “A”
 - ◆ Takes into consideration aggregate sources and differences in plant systems/technologies
- Both baseline (no WMA) and WMA need to be produced for comparison testing (minimum of 700 mix tons)



Proposed Approval Process for WMA in New Jersey

■ Material Sampling

- ◆ All mixes sampled from back of truck prior to leaving plant
- ◆ All mixes compacted at plant within 1 hour after sampling from trucks
 - Must be able to maintain compaction temperature during time
 - Plants must be able to compact specimens to 170mm tall
 - QC gyratory samples and Rice information also required



Proposed Approval Process for WMA in New Jersey

■ Material Testing

- ◆ For foaming systems and WMA < 260F, all WMA testing is required to be compared to the baseline mix (no WMA)
 - Minimum of 700 tons produced required for each
- ◆ Tentative Approval Requirements based on reduction of E* and Flow Number from baseline
 - Average E* should not decrease more than 20% from baseline (average E* for all frequencies at 45C)
 - Flow Number should not decrease more than 30% from baseline (tested at 54C)
 - Samples required to be produced to 170mm tall and air voids between 6 to 7%



Proposed Approval Process for WMA in New Jersey

■ Material Testing

- ◆ Testing will also be conducted on the QC gyratory samples to help establish comparative data
 - Rutting: Asphalt Pavement Analyzer
 - Fatigue Cracking: Overlay Tester
 - Moisture Damage: Hamburg Wheel Tracking

