Multiple Stress Creep Recovery (MSCR) testing

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- Multiple Stress Creep Recovery AASHTO TP-70
- DSR performing MSCR Identifies beneficial elastic properties.
  - Rutting Performance
    - Direct measure of Non Recoverable Compliance (**Jnr**)
    - Goal is quantify the non-linear performance of the binder to predict Rutting Performance.
      - 100Pa is in the linear region (expected behavior)
      - 3200Pa is in the non-linear region (extreme movement)

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      - **Modulus (G*) = Stress/Strain**
      - **Compliance (J*) = Strain/Stress or $^1/G^*$**

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Multiple Stress Creep Recovery

- MSCR Identifies beneficial elastic properties.
  - (2 tests in 1)
  - **Rutting Performance**
    - Direct measure of **Non Recoverable** Compliance
    - Goal is quantify the non-linear performance of the binder to predict Rutting Performance. (**Jnr**)
  - **Elastic Recovery Performance**
    - Direct measure of **Recoverable** Compliance
    - Goal is investigate differences in linear & non-linear performance of the binder (**% Recovery**)

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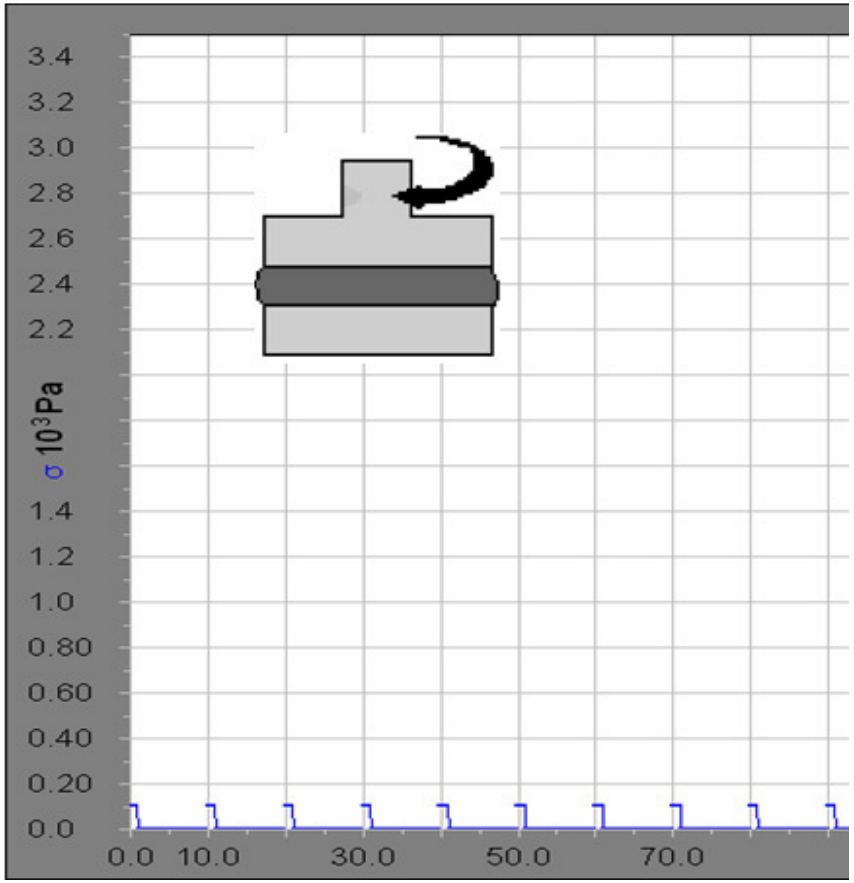
What Causes Rutting ?

Tire load applied for a short time; pavement permitted to recover for a longer time; over & over & over & over .....

For Rutting: Accumulated Strain

- Simulate pavement loading over many cycles.
- Load force applied for 1s and removed to permit binder to relax for 9s for each cycle.
- If the binder has any elastic behavior, it can be directly measured in the relaxation part of the cycle.
- Accumulated permanent deformation is a measure of the accumulated strain.
  - Non recoverable compliance (**Jnr**)



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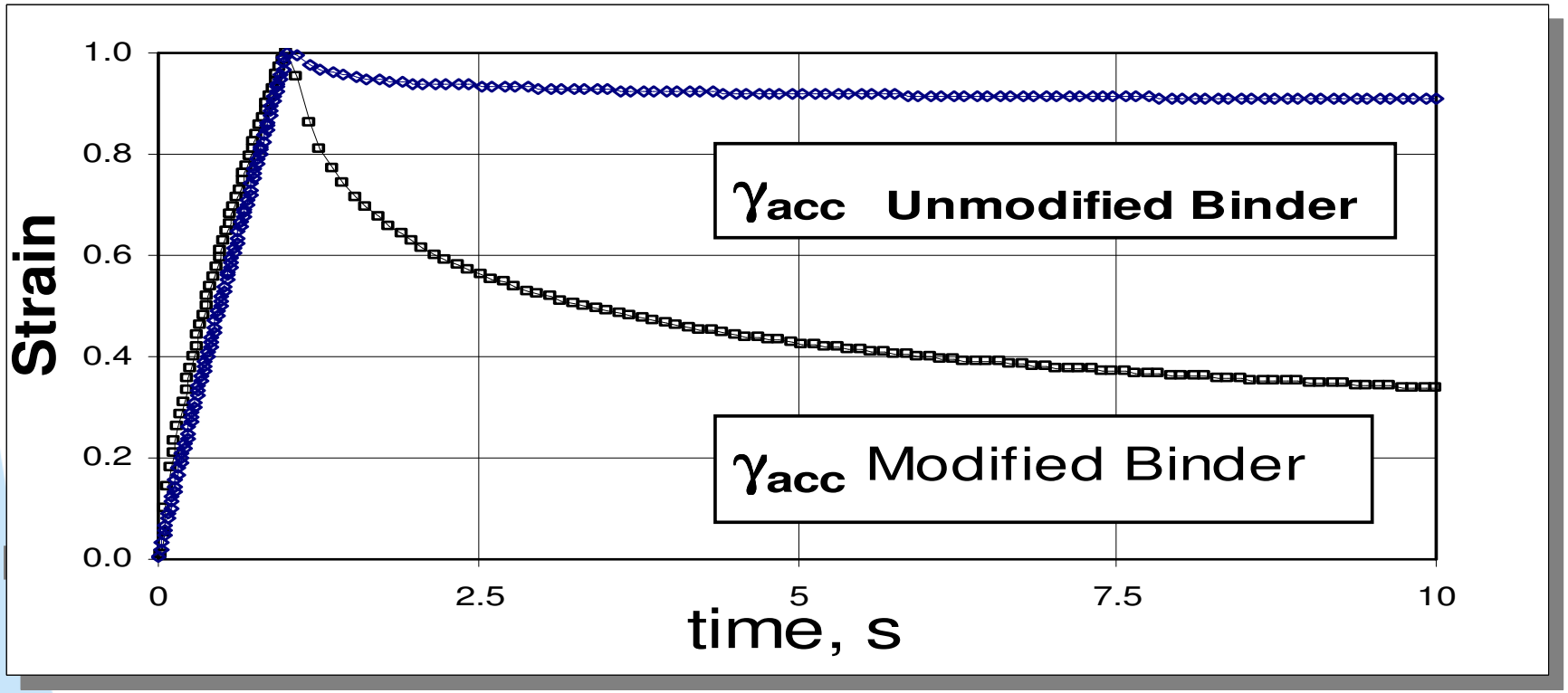
Accumulated Strain Testing

- New test procedure to evaluate binders on a DSR



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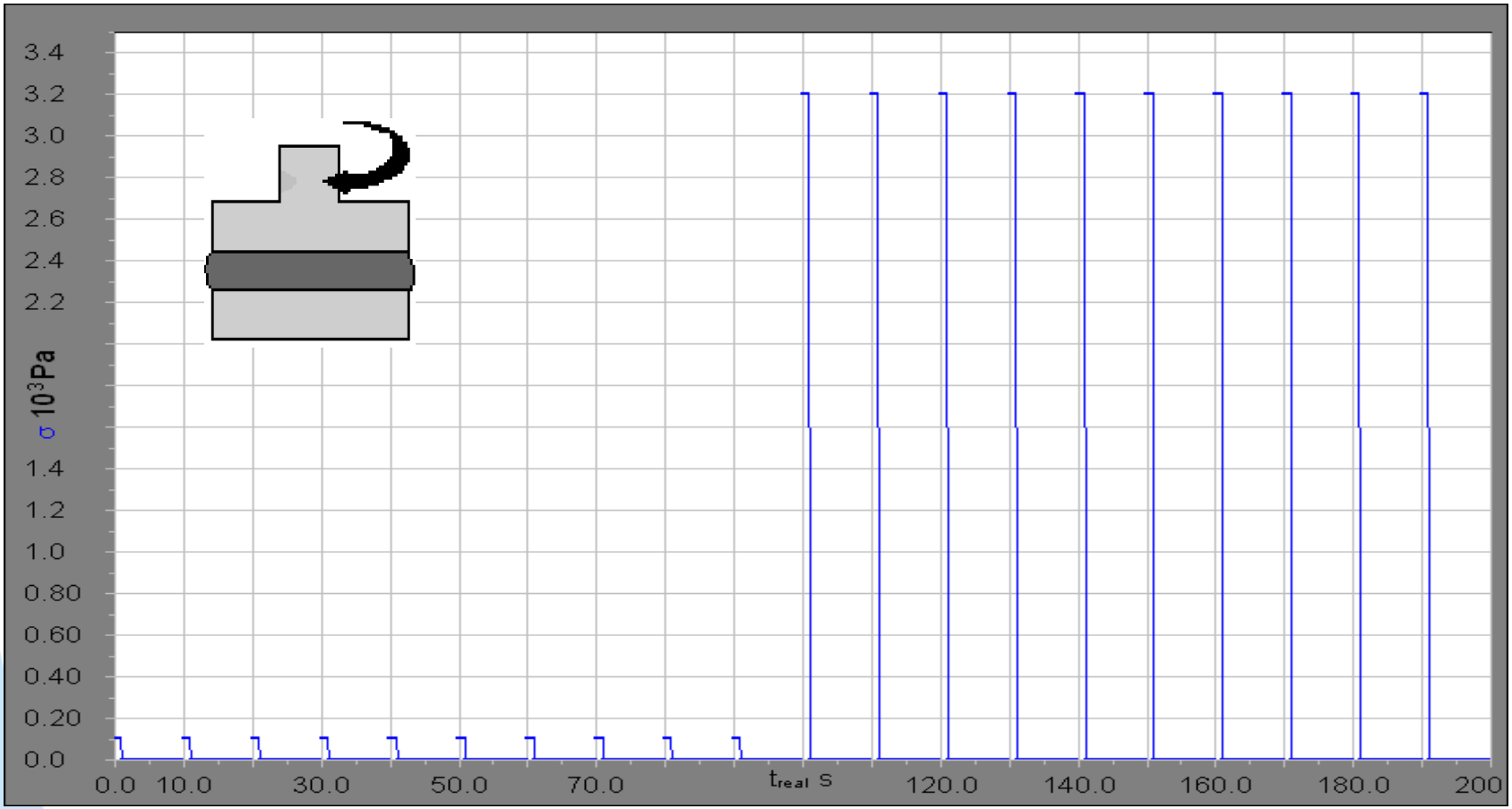
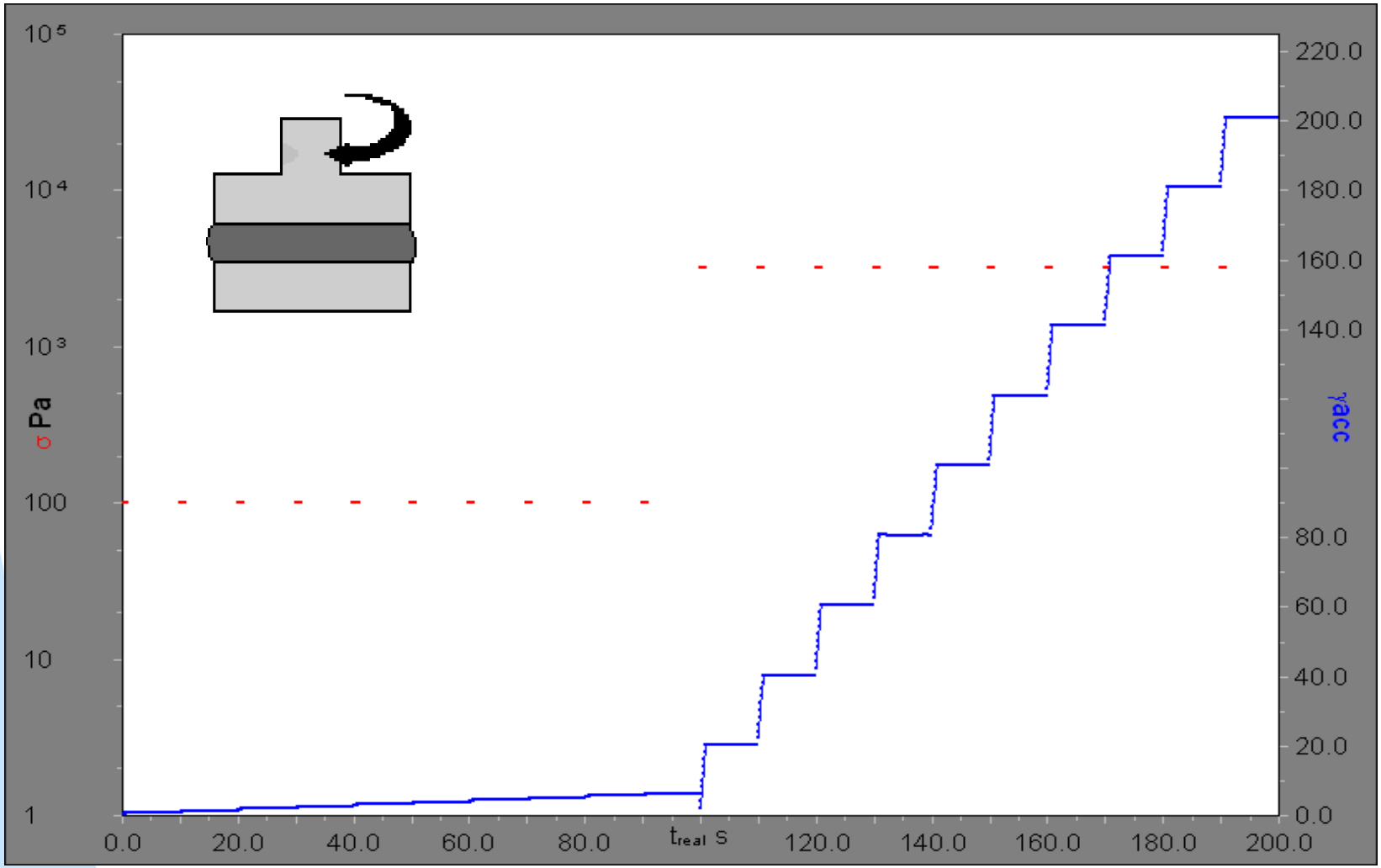
Linear & Non-Linear Applied Stress Loading



Accumulated Strain from Repeated Loading



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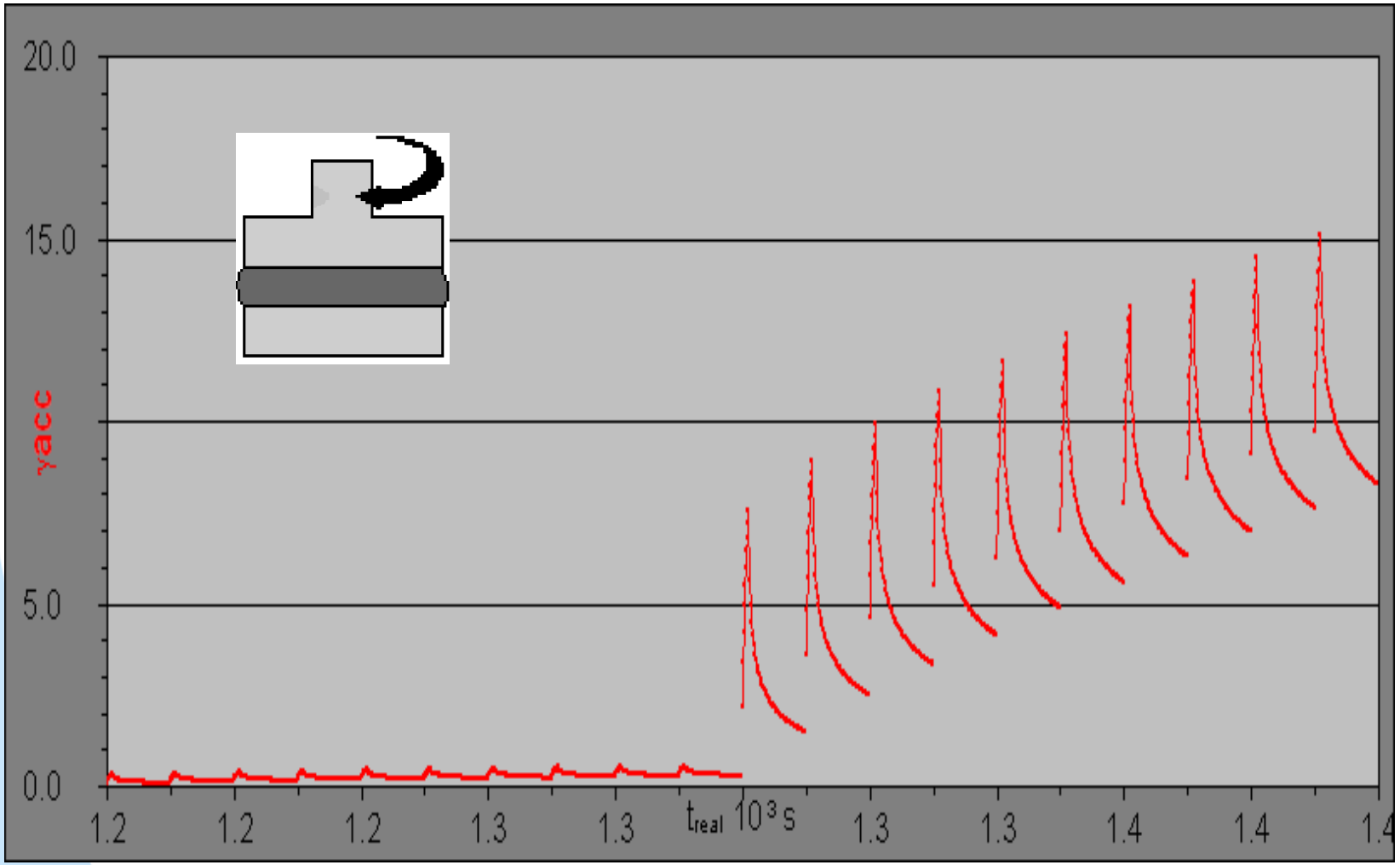
Accumulated Strain from Repeated Loading on a Modified Binder



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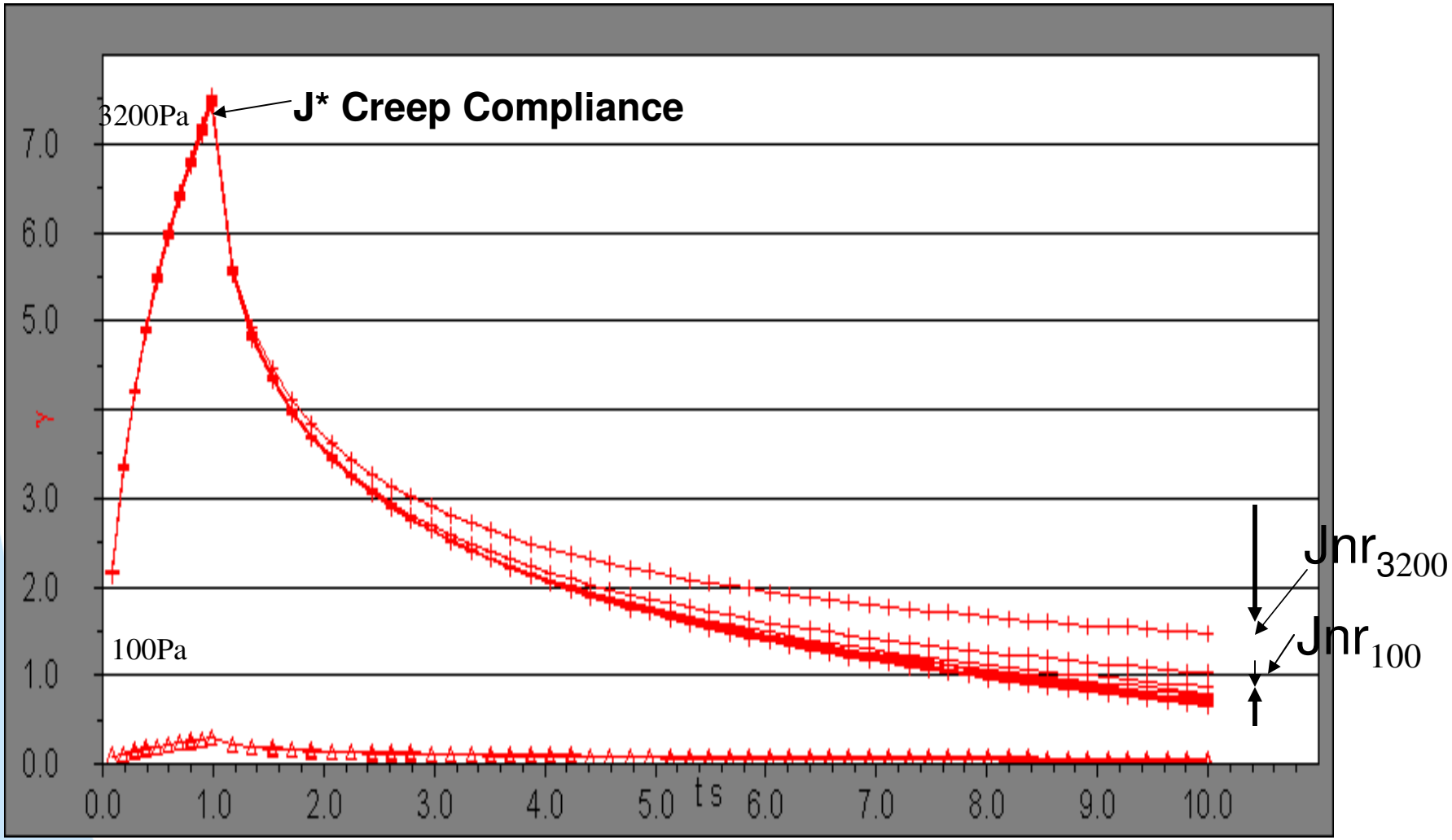
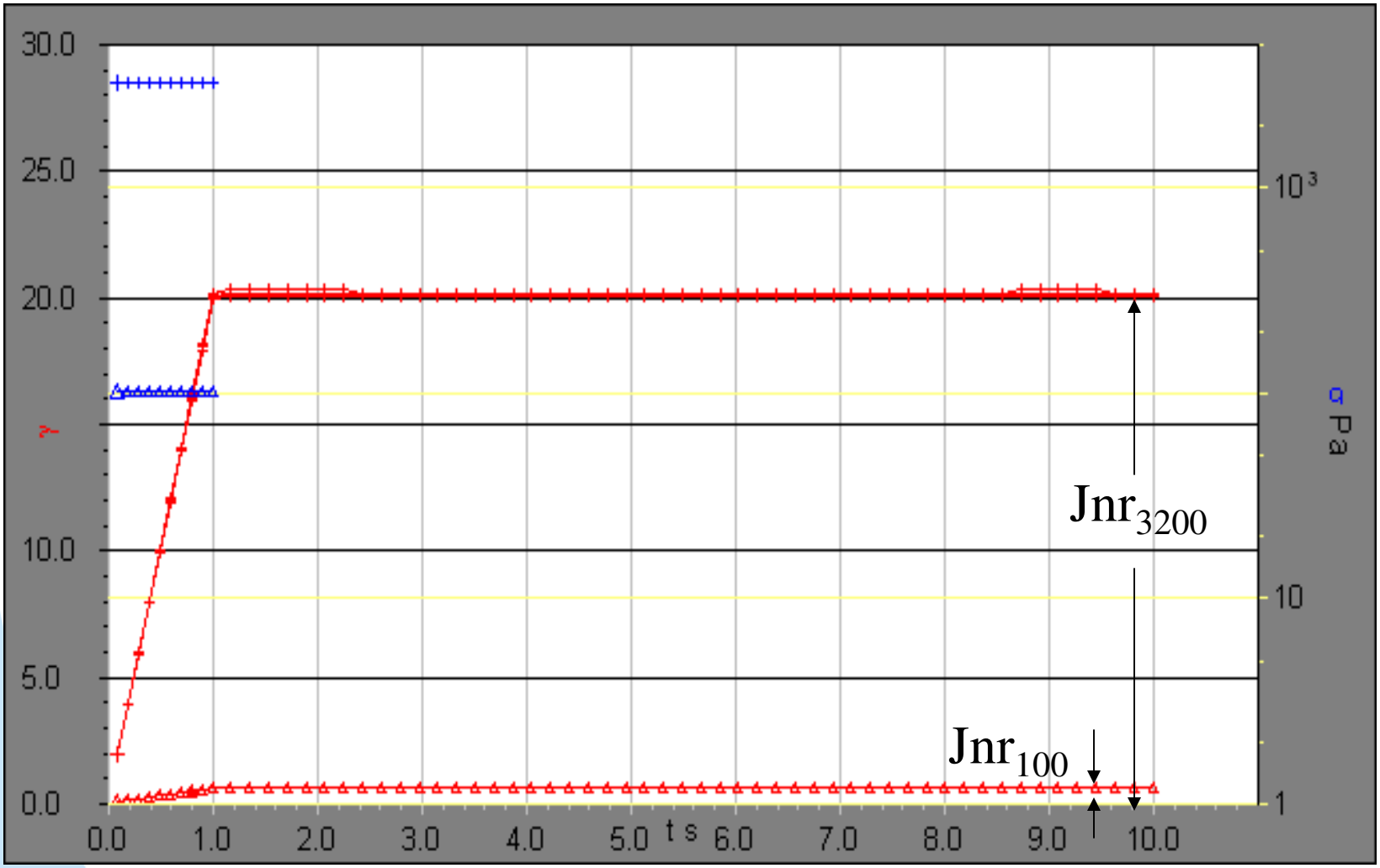
Example of a Visco-Elastic Binder

Modified binder PG70-28 tested to MSCR at 70°C



Example of a Newtonian material

Neat binder PG64-28 tested to MSCR at 64°C



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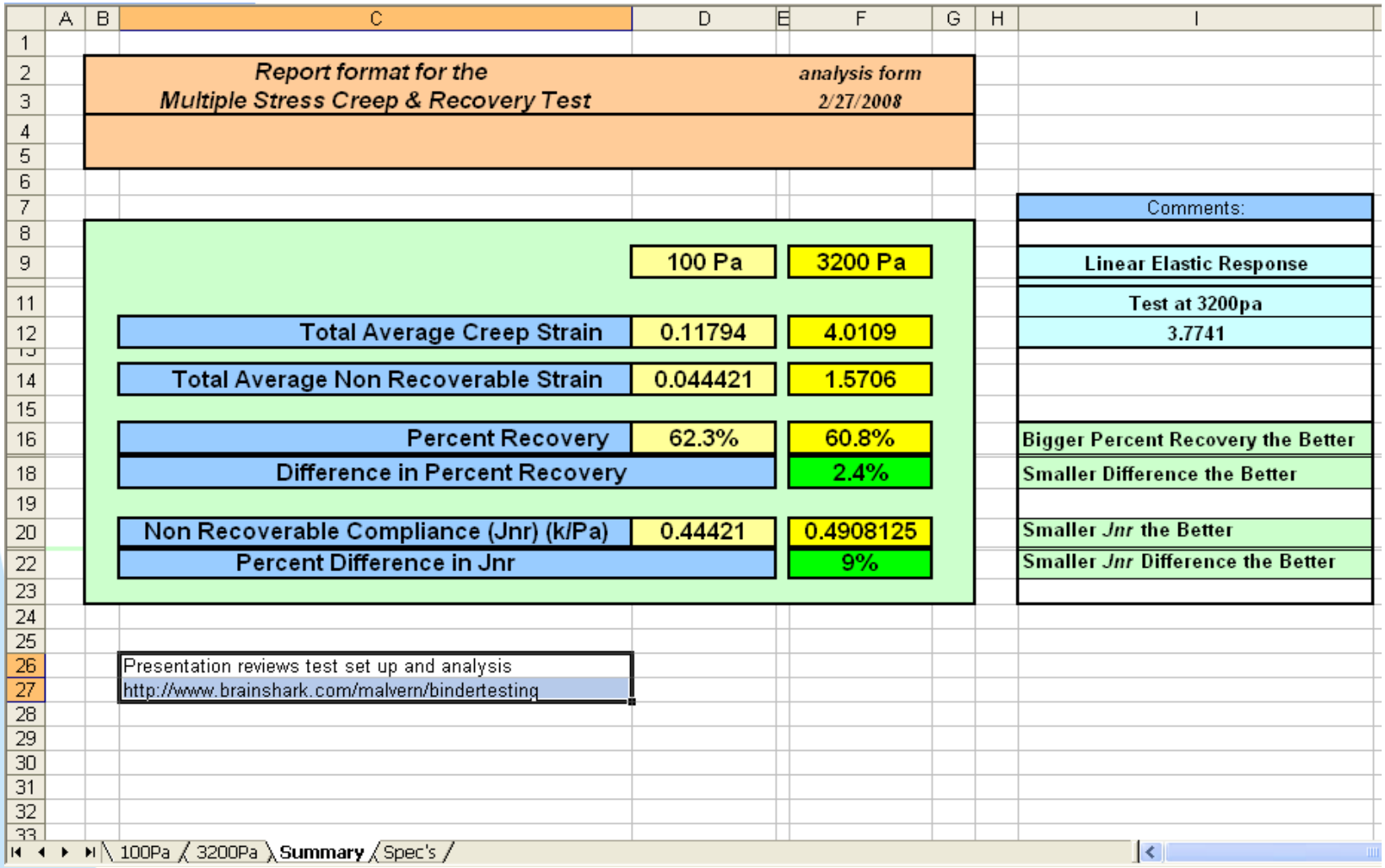
MSCR Results

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Time s	Strain	Notes										
2	0.1	0.02264								100 PA DATA	*100*		
3	0.2	0.03702											
4	0.3	0.04953								*Initial Strain for each cycle*	*0*		
5	0.4	0.06045											
6	0.5	0.07057					Sum Creep	Sum Rec		Average Creep Strain	0.11794	100%	
7	0.6	0.08043											
8	0.7	0.08975					1.1794	0.44421		Average End Strain	0.044421		
9	0.8	0.0988											
10	0.9	0.1073								Average Recoverable Strain	0.073519	62%	
11	**1**	**0.1158**			1	End Creep Strain	0.1158						
12	1.18	0.09667								Average Non Recoverable Strain	0.044421	38%	
13	1.36	0.08922											
14	1.54	0.08389								Average (Jnr) (k/Pa)	0.44421		
15	1.72	0.08043											
16	1.9	0.0775											
17	2.08	0.0751											
18	2.26	0.07297								1 sec Creep 10 Linear data points			
19	2.44	0.07137								9 sec Recovery 50 Linear data points			
20	2.62	0.06977											
21	2.8	0.06818											
22	2.98	0.06685											
23	3.16	0.06605											
24	3.34	0.06498											
25	3.52	0.06392											
26	3.7	0.06312											
27	3.88	0.06232											
28	4.06	0.06179											
29	4.24	0.06072											
30	4.42	0.06019											
31	4.6	0.05965											
32	4.78	0.05939											

100Pa / 3200Pa / Summary / Spec's /

MSCR Analysis



Report format for the Multiple Stress Creep & Recovery Test — *analysis form 2/27/2008*

	100 Pa	3200 Pa
Total Average Creep Strain	0.11794	4.0109
Total Average Non Recoverable Strain	0.044421	1.5706
Percent Recovery	62.3%	60.8%
Difference in Percent Recovery		2.4%
Non Recoverable Compliance (Jnr) (k/Pa)	0.44421	0.4908125
Percent Difference in Jnr		9%

Comments:

- Linear Elastic Response
- Test at 3200pa
- 3.7741
- Bigger Percent Recovery the Better
- Smaller Difference the Better
- Smaller *Jnr* the Better
- Smaller *Jnr* Difference the Better

Presentation reviews test set up and analysis
http://www.brainshark.com/malvern/bindertesting

100Pa | 3200Pa | **Summary** | Spec's

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Passing **Jnr** Values for MSCR

- All testing is at the environmental use temperature
- **PG 64-28S** or **PG 64-28H** or **PG 64-28V**
  - **S**: Standard Grade = **4**
  - **H**: Heavy Grade = **2**
  - **V**: Very Heavy Grade = **1**
  - ***E****: Extremely Heavy Grade =* ***0.5*** *(special applications)*

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AASHTO MP-19

A New Spec Much Like M-320

Original					
DSR G*/sinδ Min 1.0	**64**				
RTFOT					
64 Standard MSCR3.2 <4.0	**64**				
64 Heavy MSCR 3.2<2.0	**64**				
64 Very heavy MSCR3.2 <1.0	**64**				
PAV					
S grade DSR G*sinδ Max 5000	**28**	**25**	**22**	**19**	**16**
H & V grade DSR G*sinδ Max 6000	**28**	**25**	**22**	**19**	**16**

Low temp BBR and DTT remain unchanged

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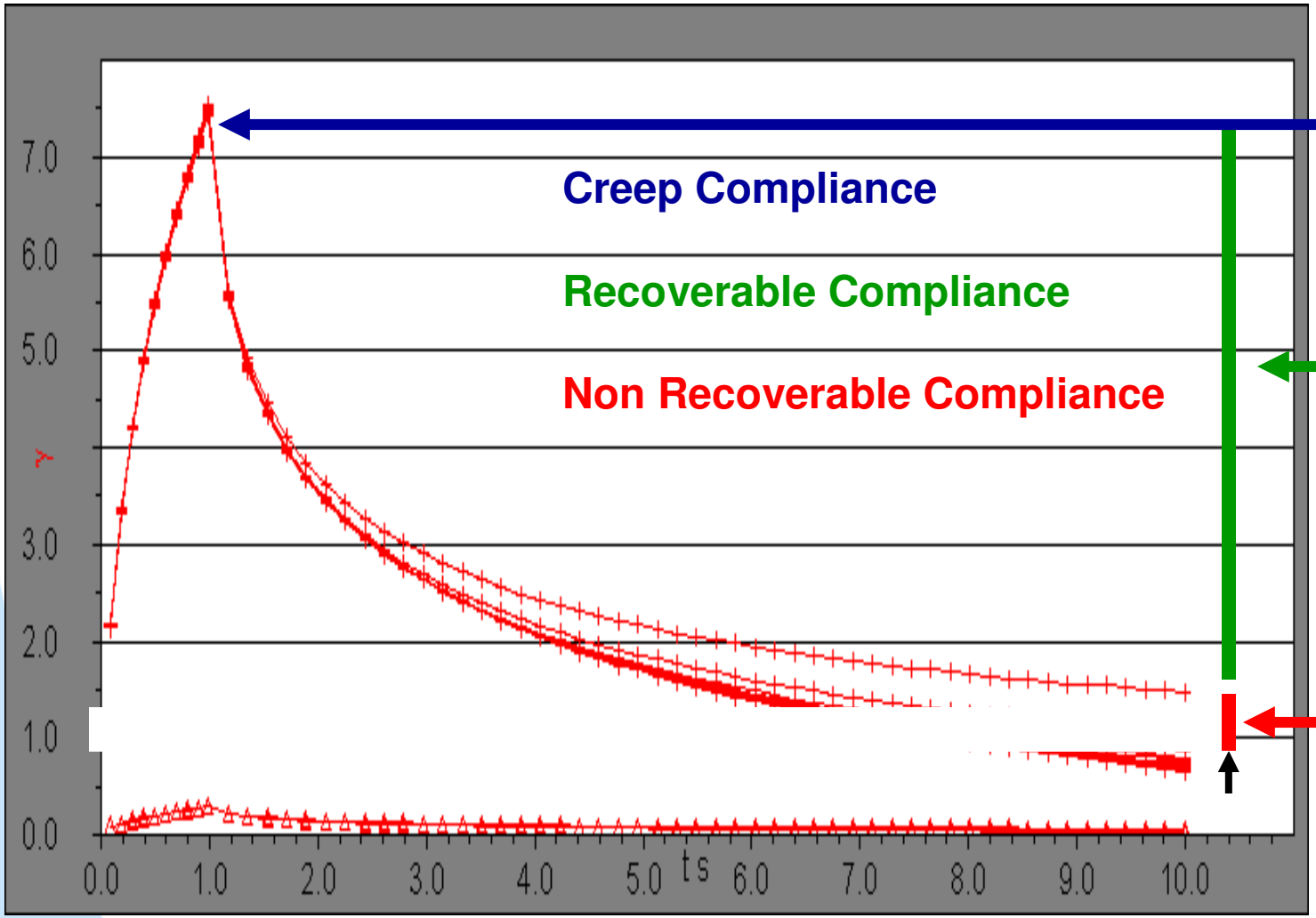
What's Really Going On?



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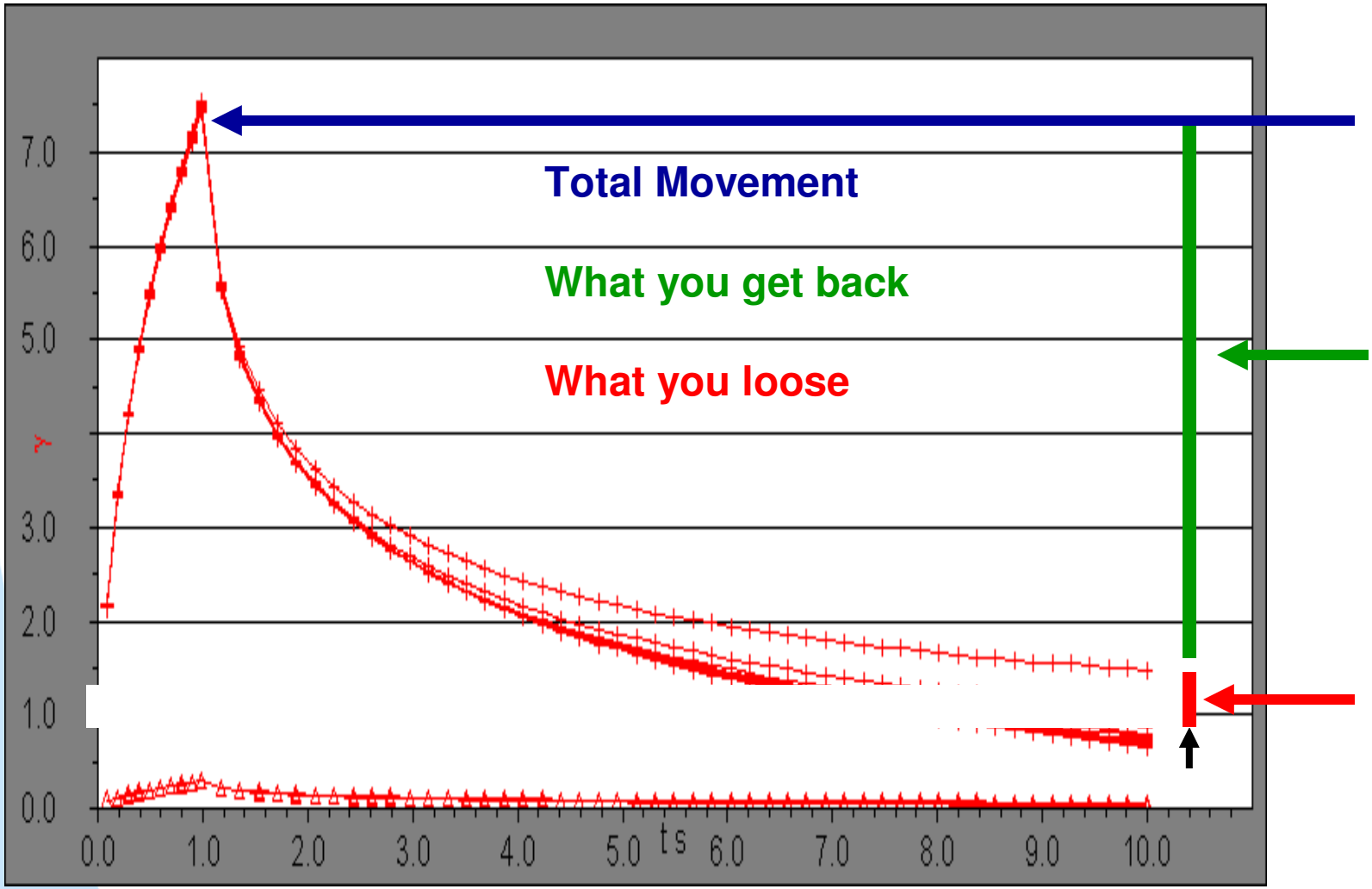
How Does It Relate To % Recovery



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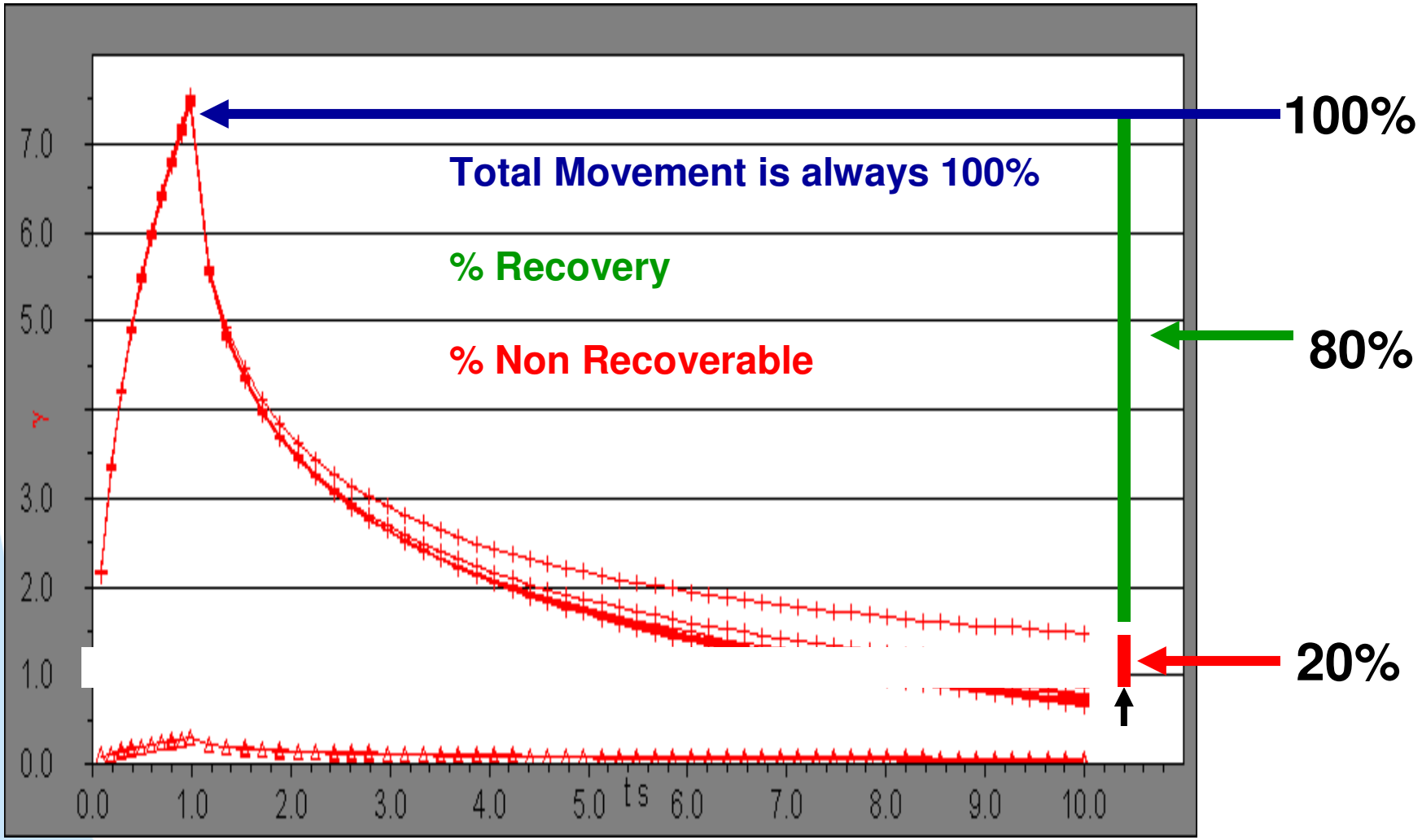
How Does It Relate To % Recovery



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% Recovery

- Tested at Environmental Temp vs. Elastic Recovery (ER) at 25C.
- Relates to ‘Good’ Elastic Recovery Performance.
- Data is Free. You get it from TP-70

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Common Problem

- Some report negative (-) Recovery values
  - Generally due to low G* samples or samples with very little elastic behavior.

- **Solution:**
  - Test at lower temperatures, if possible.
  - Increase amount of modification to improve elastic contribution in the measurement.
  - Test on an instrument with low instrumental inertia.

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Thank you for your Time!

Questions ?

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