PRACTICAL EVALUATION AND HANDLING OF BOWED ROTORS
AND
SELECTION OF BALANCING METHODS

EVALUATION AND HANDLING OF BOWED RIGID AND FLEXIBLE ROTORS PRIOR TO BALANCING IN SHOP

BY

Zlatan Racic and Juan Hidalgo

PRACTICAL EVALUATION AND HANDLING OF BOWED ROTORS
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- 1 *Purpose of balancing*

To create the centrifugal force from placed weights, at specific locations on a rotor, to counteract the centrifugal force and moments created by randomly distributed mass eccentricities along the rotor.

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- 2 *The Goal of Balancing*

The goal of balancing is to obtain good running characteristics of the rotor at operating speed, as well as over the entire speed range, particularly at critical speeds.

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- 3 *Balancing Results*

  - Reduce dynamic loads on bearings
  - Reduce shaft deflection within operating clearance confines
  - Reduce transmission of forces to outside environment
  - Reduce shaft dynamic stress

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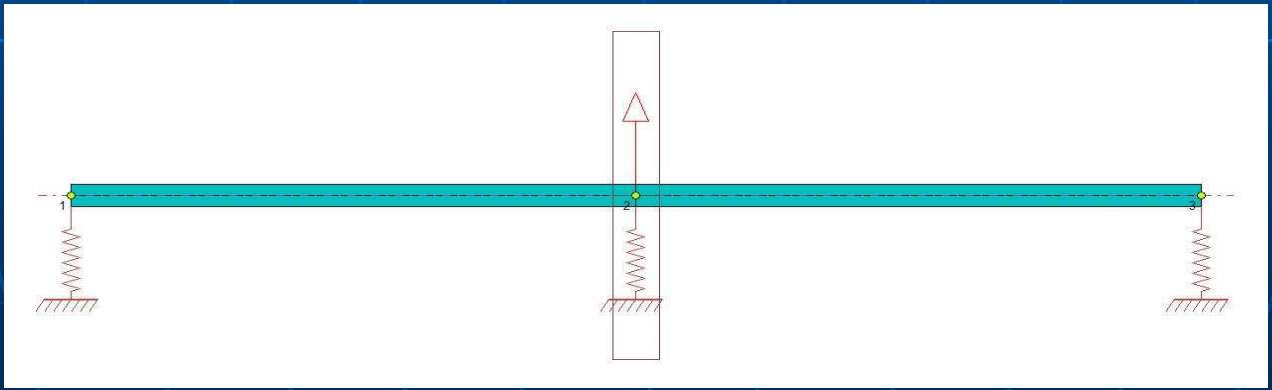
- 4 *Simple Balancing*

The simplest way to learn and to demonstrate balancing is utilizing the Jeffcott Rotor model, with a single mass with, or without a bow in the shaft.



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- *5 Bowed Rotor Balancing Effects*

A bowed rigid rotor is easy to balance in isolation (in shop) to satisfy bearings or shaft vibration criteria. The problem arises after the rotor is coupled, in machine , to other rotor.

A well balanced bowed rotor in the shop does not guarantee good operation after coupling up to other rotors in the train.

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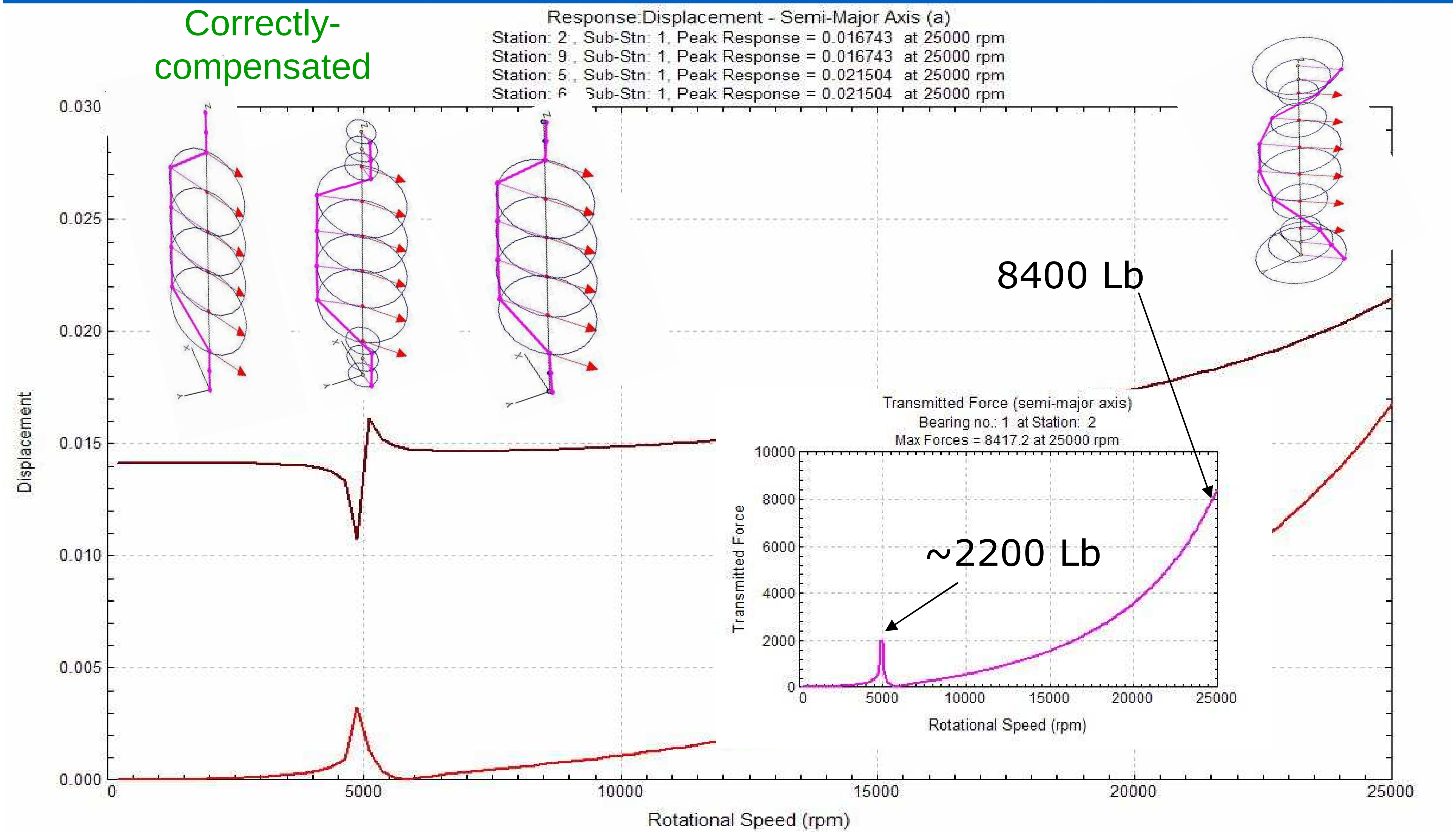

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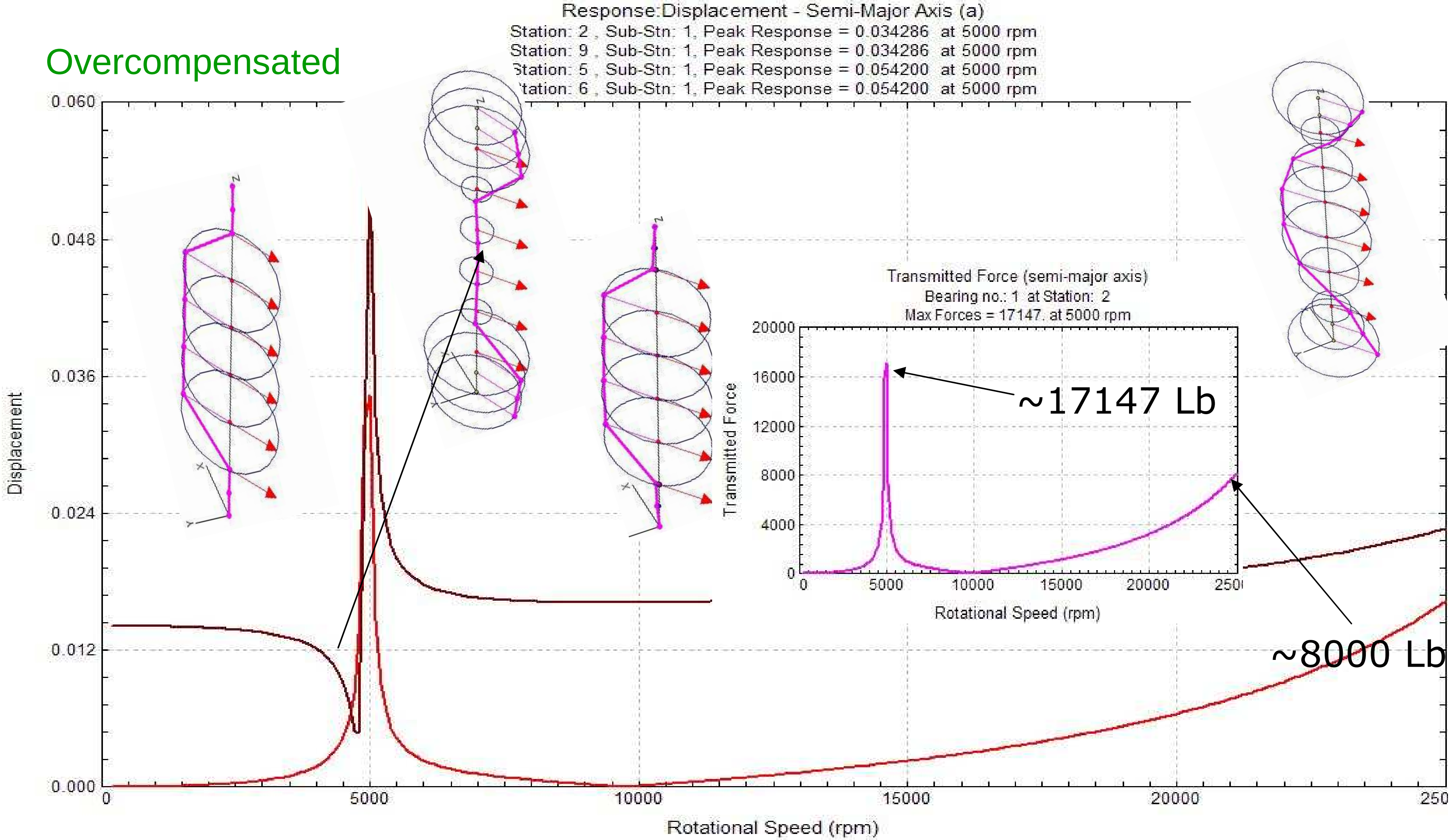
Overcompensated



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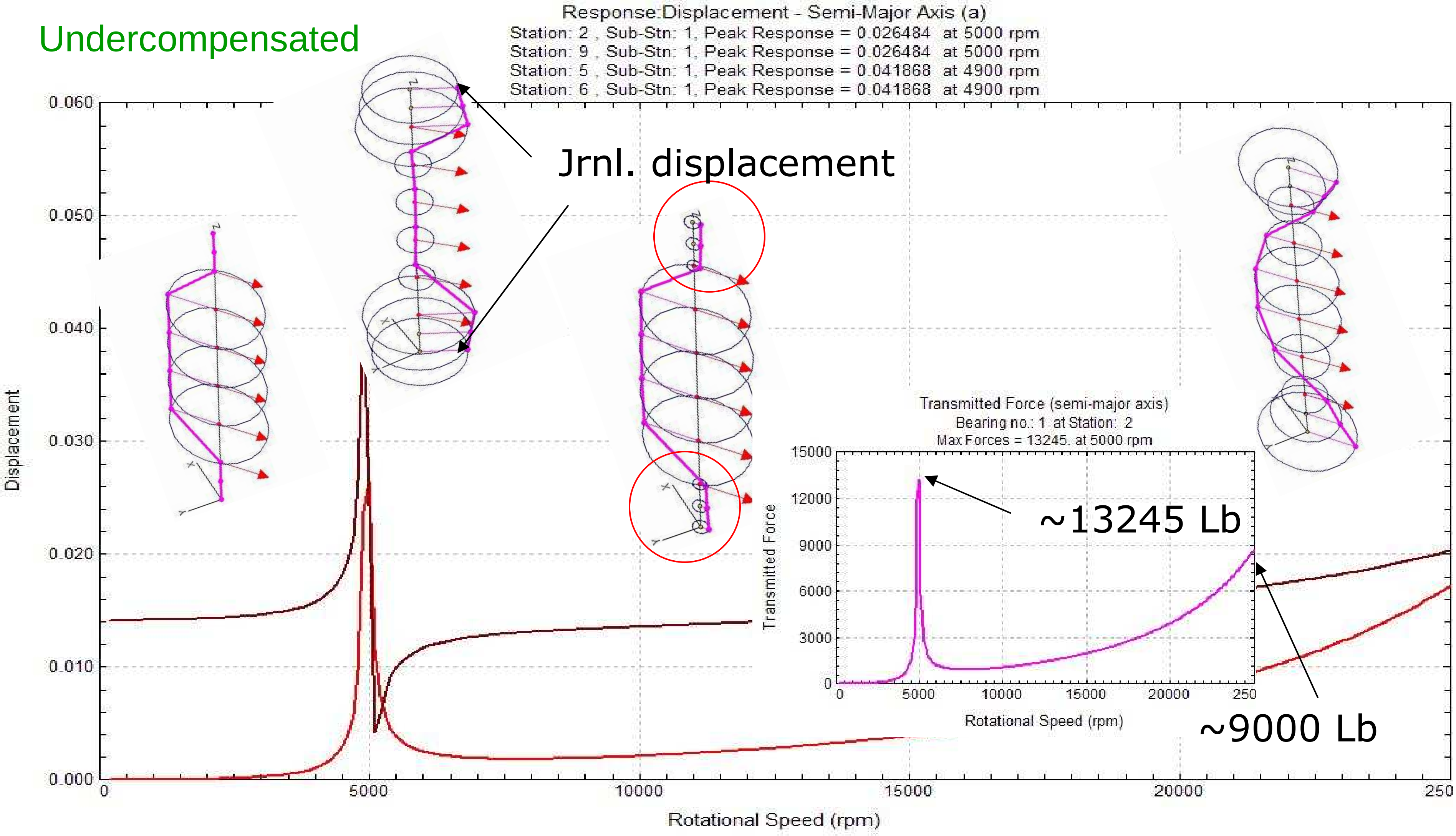

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- *6 Rigid Rotor Coupled Within Train*

The effects of a bowed rotor on train behavior depends on many factors, among them:

- Rigidity and mass of adjacent rotors
- The amount and angle of deviation of mass centerline from the rotational centerline.

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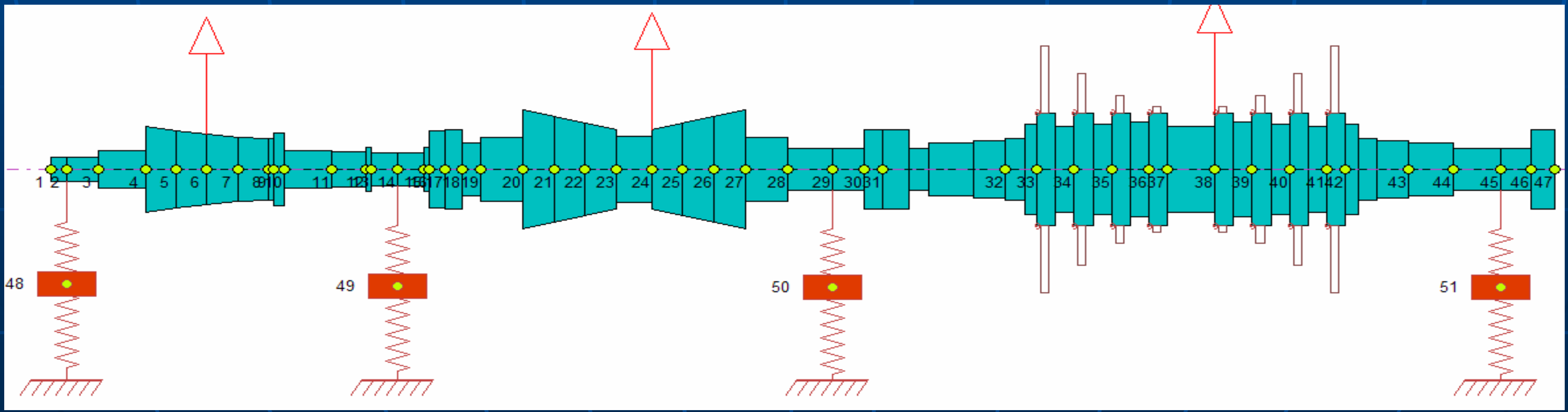
- *7 The Effects of an IP Bowed Rotor*

- Induces unbalance in HP rotor

- Causes high shaft amplitudes and rubs

-Causes high bearing loading and wipe.



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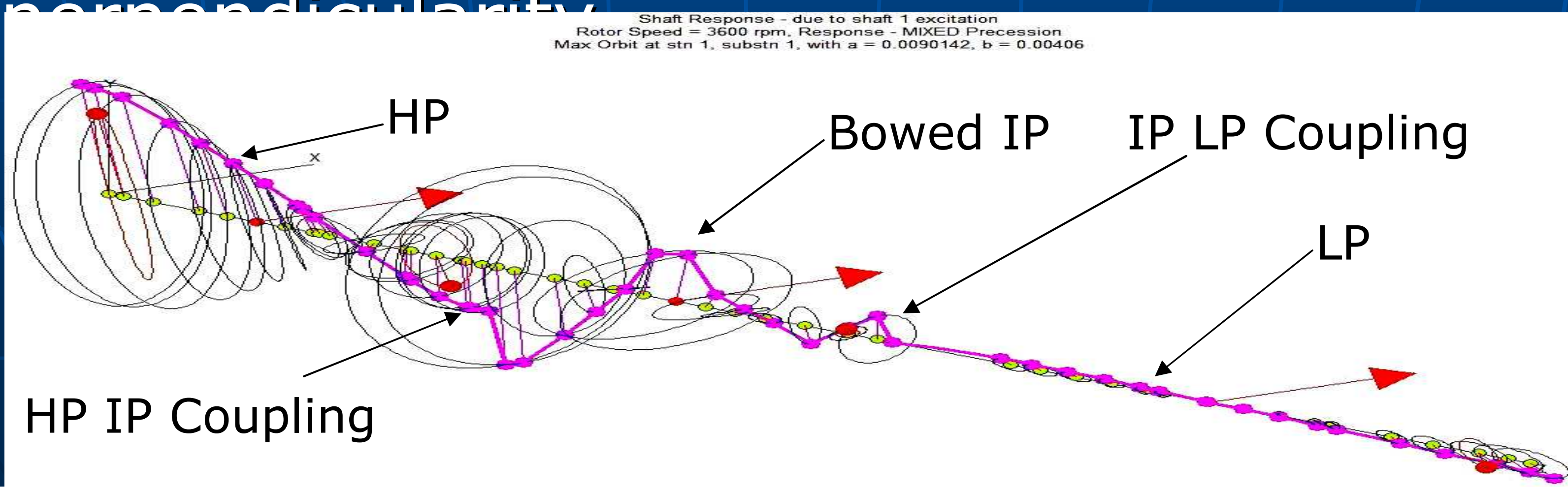
- *8 Indirect Effect of a Bowed Rotor*

-A Bowed rotor, e.g. shop balanced IP, produces high motion on the adjacent perfectly balanced HP rotor due to coupling eccentricity and out of perpendicularity



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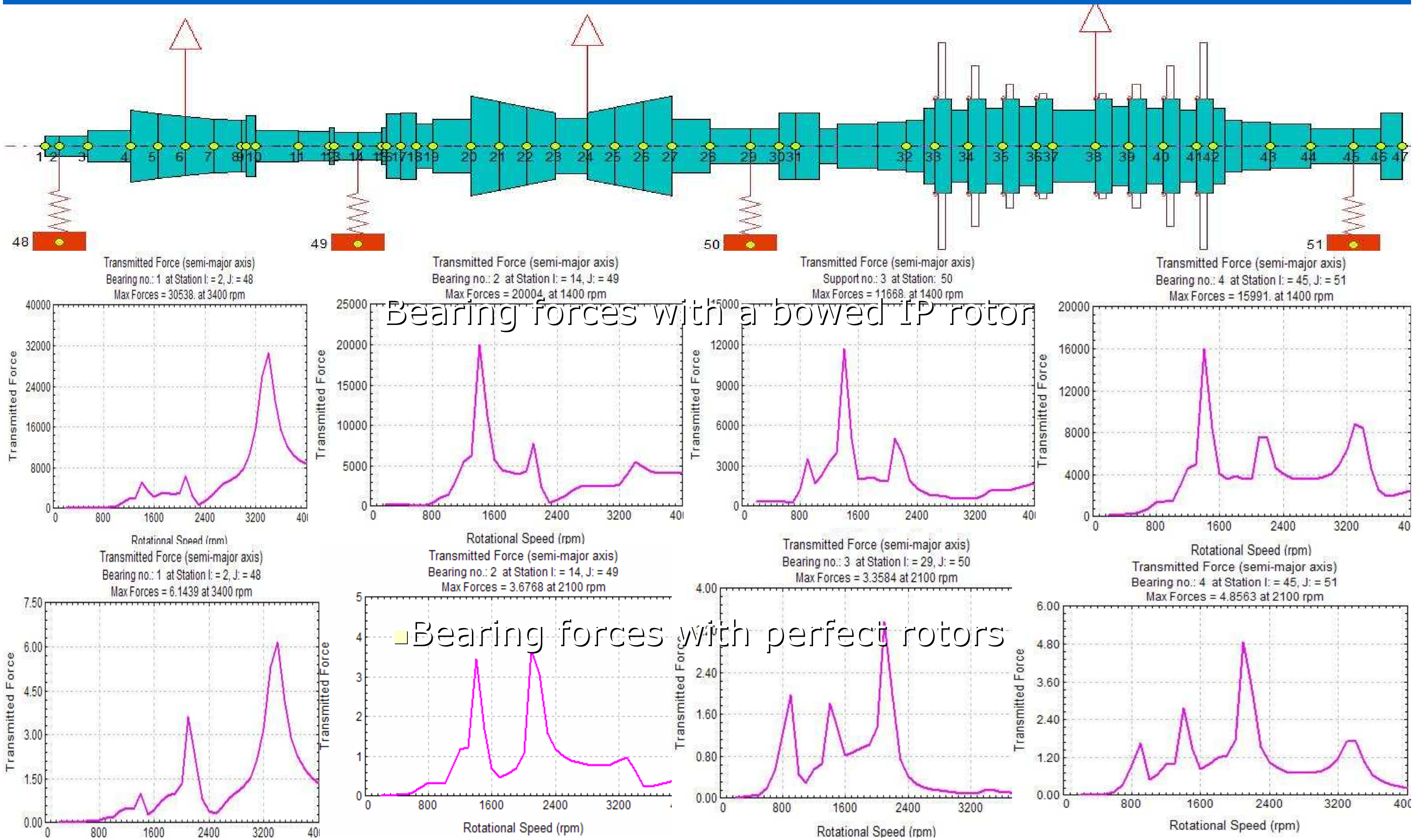

Bearing forces with a bowed IP rotor

- Bearing forces with perfect rotors

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- *9 Balancing Flexible Rotors having large eccentricity*

-When dealing with very elastic rotors having large distributed eccentricities over its body, using distributed corrective weights instead of concentrated weights, have the following advantages:

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-Lower transmitted bearing forces at 3^{rd} critical (Important because very flexible rotors operate at or near their 3^{rd} critical)

- Lower dynamic bending moments, specially at mid-span, where there is a maximum gravity sag.

- Eliminates the possibility of rotor developing unusual “Thermal sensitivity”.

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- Simpler methodical balancing process, lower the number of runs in a bunker, and reduce the total weights needed for correct balancing.

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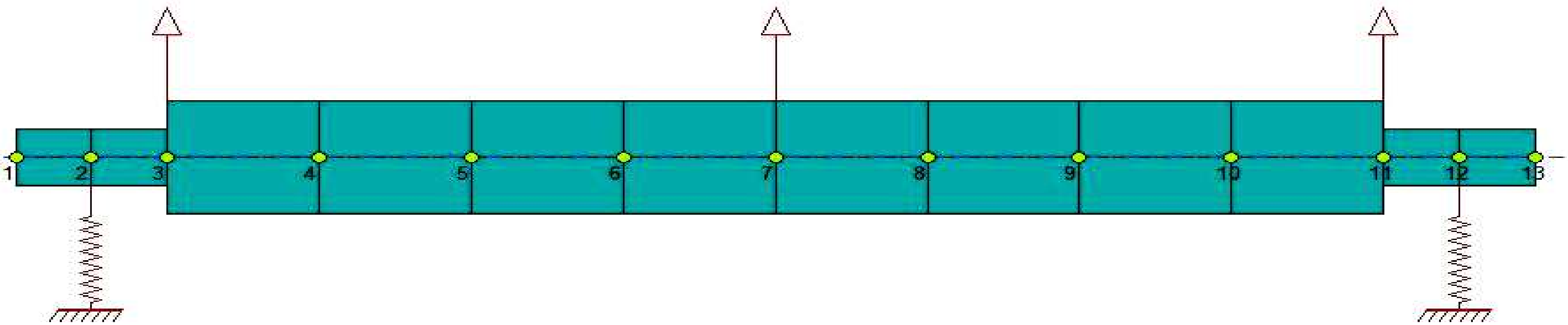
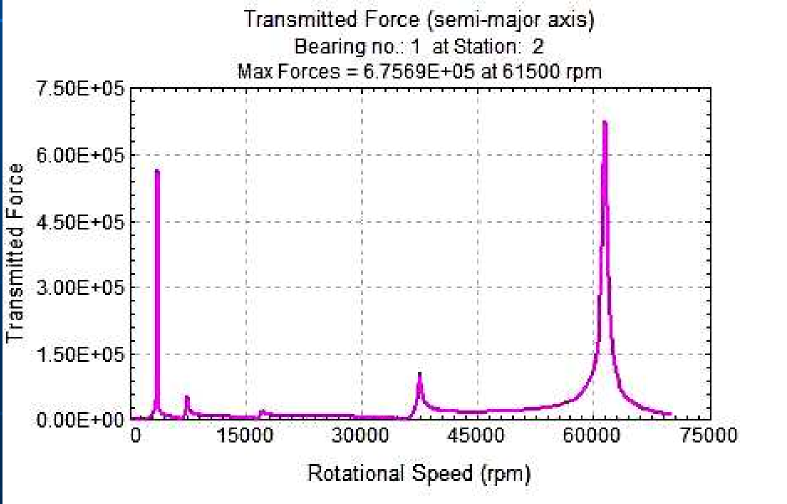
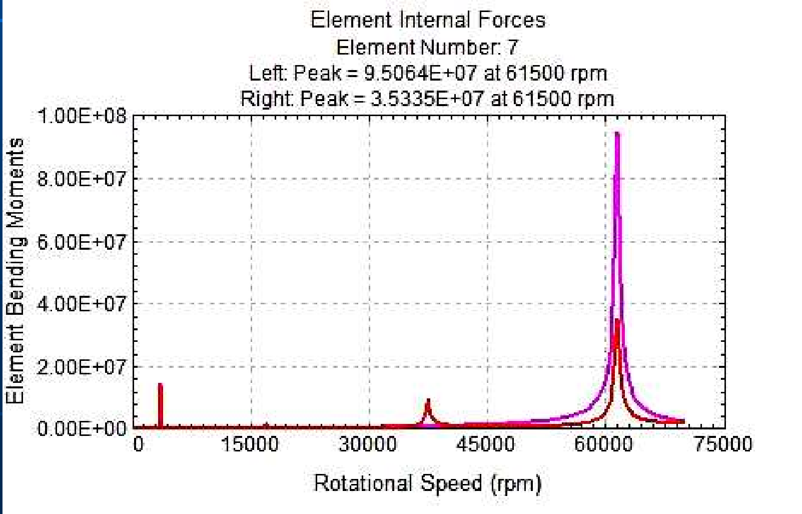
Flexible Rotor Balancing with Concentrated weights (N-Method)







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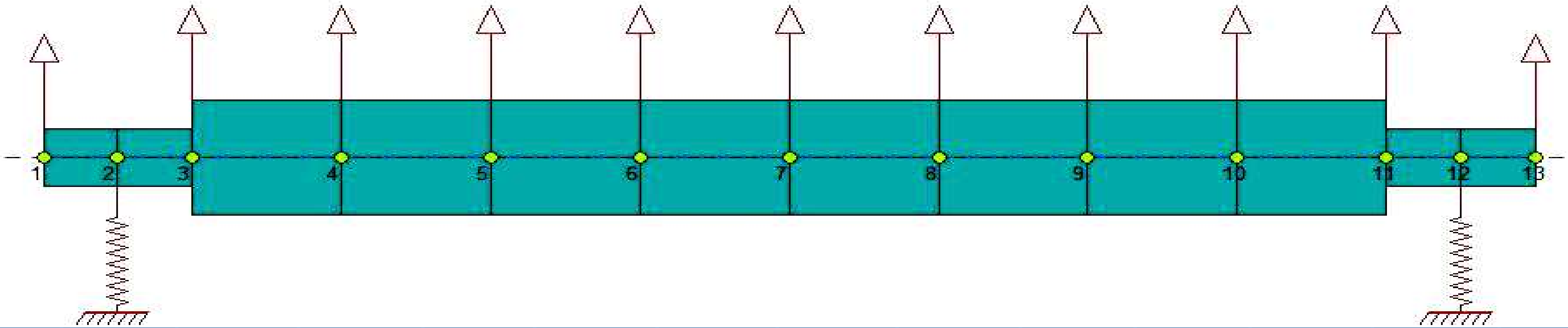
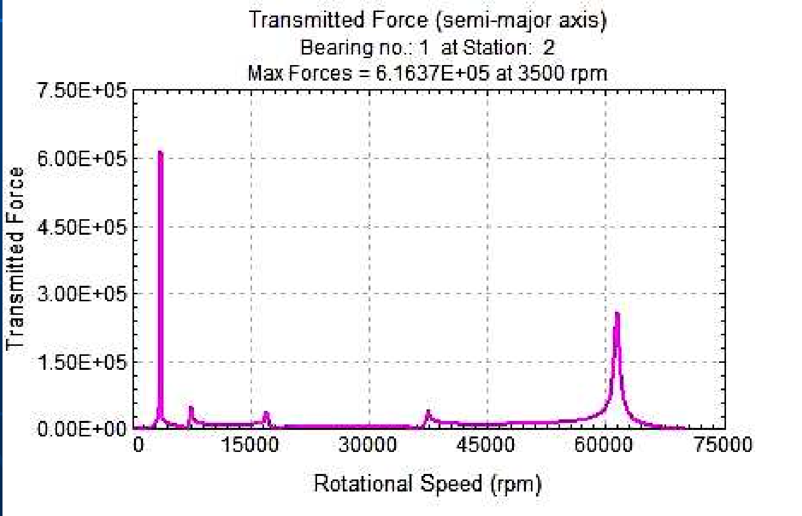
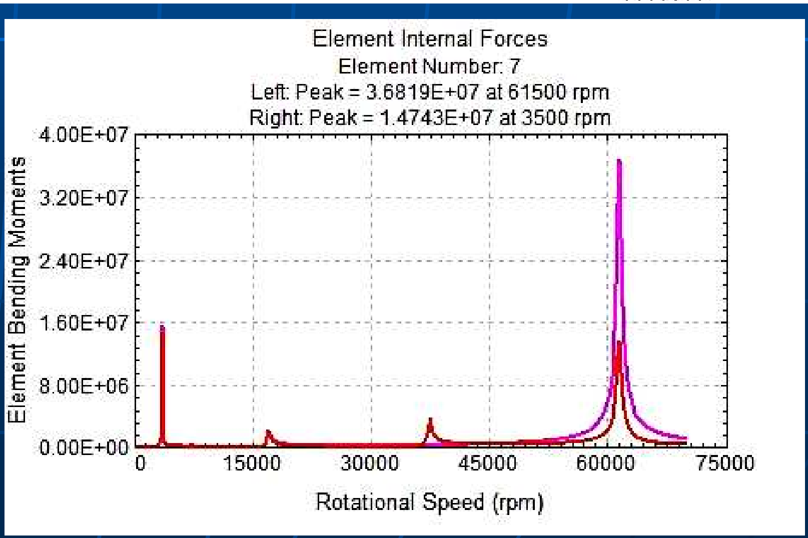
Flexible Rotor Balancing having large body eccentricity
Rigid mode balancing in multiple planes at first critical, then pure modal balancing.







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CONCLUSION

- Many balancing methods are applied today in practice, and all give equally good results, when balancing rotors with close to OEM machining tolerances.

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cont……

- There is no “better” or “worse”, balancing method, only the more or less economical in a given situation, and none gives a unified method which would satisfy every rotor.

cont….

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Cont….

- Rigid mode balancing method using at least N+2 number of planes, at rotor's lowest measured "critical", based on evaluated eccentricities, is superior to other methods, when balancing rotors with deformations, e.g. bow. With this method rotor is first "dynamically straighten", prior to continuing with modal balancing.

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- Measuring rotor eccentricities (in shop) prior to balancing, at low speed or at rated speed, provides an opportunity for the assessment and a selection of an appropriate repair process, prior to balancing. (Thus avoiding unaccountable disputes later)

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Cont…..

- With utilization of FE modeling of rotors, many machine rubs and bearing “wipes” and other damages, can now be explained, previously left unexplained or explained incorrectly.

END

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Questions and Comments ?