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Unapproved Minutes of the January 24, 2013
Sequence IV Surveillance Panel Meeting held in San Antonio, TX.

A copy of the Agenda is included as Attachment 1

The attendance sheet is included as Attachment 2. Also in attendance via teleconference line were Andy Ritchie and Mike McMillen representing Infineum and Tim Miranda representing Castrol. Membership changes noted during the meeting were to replace Mark Sutherland with Jo Martinez for Oronite and to replace Eric Liu with Fred Gerhart for Southwest Research.

Bill Buscher agreed to be the motion and action item recorder for the meeting.

Minutes from the July 17, 2012 Conference call were approved.

Review of Action Items;
The following is a status of action items from the previous meeting

Motions and Action Items

As Recorded at the Meeting by Pat Lang

1. Action Item – Surveillance panel chair to contact Nissan to inquire about the potential for Nissan to make an additional test kits. Working with Nissan, it appears to there is potential to obtain additional hardware. Chair to meet with Nissan in early February, to be discussed in detail further today.

2. Action Item – SwRI to investigate solution to mild cam batch situation to determine if the mild cams can be brought to an acceptable severity level. Ongoing, to be discussed during today's meeting.

3. Action Item – Surveillance panel chair to solicit suppliers for a GF-5 technology reference oil with ACW performance in the 50 to 90 µm range. One supplier has expressed an interest in possibly supplying an oil, ongoing.

4. Action Item – TMC to reassign RO 1009 assignments that are for the IVA to the VG. Completed.

5. Action Item – Form a task force to further investigate driveline dynamics and the effect on camshaft wear. The task force will be lead by Eric Liu with the following members: Al Lopez, Jerry Brys, Mark Mosher, Rich Grundza, Tim Claudill, Christian Porter and Bill Buscher. On going, report from Eric Liu under item 12.

6. Motion – Remove RO 1009 from the IVA LTMS. Completed.

Fuel Suppliers report. A copy of the Certificate of analysis is included as attachment 3. There were no questions or comments raised for the fuel supplier. It was noted that the IVB test may be run on EEE fuel, depending on how the severity of initial tests performs.

Hardware Issues.

Based on the most recent IVA hardware survey, most labs estimate they will be out of parts by 2014. Activity level has been higher than expected. One lab indicated they ran 99 tests in the 2nd half of 2012 when they had ran 53 tests in the first half of 2012. Based on current estimates, it appears that industry will need somewhere between 550 and 600 tests worth of hardware to see testing through 2016. There is potential to obtain another parts solicitation from Nissan, but the hardware is no longer "production" hardware and is now "service" hardware. Bill was unsure what this means and wasn't sure if this hardware will be batched, that is identified with a batch code designation. Bill indicated that gaskets are available and cylinder heads as well. However, heads are bare and will need to have the individual components procured as well and heads will need to be assembled. Over the past few years, the number of runs which a head and block can be run have been increased, and some engines and heads are available which have runs left on them. It was suggested that perhaps some of these heads/blocks can be reinstalled and the remaining runs be used. A suggestion was made that perhaps the number of runs can be increased. One issue that may cause engines to no longer be used is blowby. Once blowby gets to approximately

16L/min, the ability to maintain front cover flow is negatively impacted. It was suggested that perhaps the number of runs can be increased to 48 and 24 for blocks and heads, respectively. Oil coolers are also an issue and are no longer available. An adapter can be made to allow the use of the Sequence III cooler, which can be supplied for the foreseeable future. The sequence III cooler is nickel plated, and this cooler can be obtained without plating. ECM's are no longer available, however, there are remanufactured units available from a supplier, Americore Auto.com, the ECM is ECV-RR-SVC. OHT had 4 harnesses in stock, but all have been sold. Labs are to send any failed harnesses to OHT to be evaluated for possible rework.

Discussion next centered around ways to make some "mild" cam batches usable. It was suggested that one way to address some of the severity issues was to potentially regrind cams. Bill Buscher indicated that Southwest had a number of cams reground and the performance of these cams was on target. Considerable discussion ensued regarding the modification of these test parts and the reasoning behind modifying hardware. Bill explained that in screening some of these new camshafts, they noted that there is a 3 – 5 micron convexity on some camshaft batches. When confronted with this, they began to measure each camshaft prior to testing, determining the convexity, then including this pretest value in the total wear value. When confronted with measuring each cam prior to testing, the laboratory sought a way to eliminate the pre-test measurement. The laboratory contacted OHT and asked if they could have the camshafts reground, which is a normal operation for the camshaft supplier. OHT confirmed that these camshafts could be properly refinished. OHT's vendor used to manufacture this camshaft and OHT paid them to reverse engineer this material to confirm the profile, surface finish, etc. The profile of the camshaft is unaltered during the refinishing process. OH Technologies, Inc. was unaware of any intended purpose of this material being used in an ASTM method without the knowledge of the Surveillance Panel. Jason Bowden stated OHT told SwRI that it was OHT's position that if this material is going to be used in the ASTM test method the Surveillance Panel should be notified Approximately 150 tests were determined to be run with reground cams. Several members expressed concerns about the process of regrinding cams and that it was in effect, modifying test hardware, and this activity should not be done without advising the surveillance panel. Bill indicated that batches NK9X230 NK04120 and NK05190 had all been reground and used for reference and candidate tests. There was some uncertainty about whether some of 087230 cams may have been reworked. Al Lopez raised the question of whether he would have to regrind NK cams in his lab, since Southwest had modified these batches of cams. There was no clear direction on this item in the panel discussions. Bill reiterated the changes the panel had made to the test to deal with severity, which included driveline and mounting issues and standardization of blowby measurements. There were questions about the regrinding process and Jason Bowden explained that the cams are ground to a certain height and the entire lobe and cam is reground. Bill also noted that some of the 99 cams exhibited a surface change relative to other batches. They had attempted plasma cleaning which was able to move the severity of these cams, but attempts to regrind these did not alter severity. There is no print available for this cam and Bill suggested there may be some 300 cams which may require rework in industry. When asked about potentially allowing this practice, several members commented that the engineering behind this approach appeared to be sound, but the needed more details to make a decision on whether the practice should be acceptable. After more discussions about the regrinding, a motion was made for Southwest to draft a report detailing the cam batches, number of tests and timeline for the measurement changes and the regrinding process. This report is to be included in the minutes from this meeting with a date for completion as the end of business January 31, 2013. This report is included as attachment 4.

Plan to Sustain Test through 2016.

The next series of discussions were centered around what actions need to be taken to make available hardware to meet testing requirements through 2016. There was some discussion about the 990727 cam lot. One lab had identified these cams as mild and another lab had shelved them because of the 1st labs experience. Since this situation was identified, a third laboratory had successfully calibrated on this lot. The first lab intends to run these cams, after appropriate references had been conducted on this hardware. This lab believes that the severity may not be so much cam related as issues with driveline that were identified much later. Discussions then centered around whether correction factors could be used on mild

hardware batches and whether another source of cams could be found. OHT has a supplier who manufactured this cam, but the issue may be the availability of followers to be used with the cams. Al Lopez indicated that followers may be available from abandoned cam lots. Correction factors were not favorably viewed by the panel as they may be lab based and might be quite large, given some of the lot performances in the past. These actions were thought to be unnecessary as it appears Nissan will make available additional hardware. Oil coolers were then addressed. The Nissan Cooler is no longer available. One lab is out of coolers. OHT has an oil cooler that is used for Sequence III tests that can be adapted to the Nissan engine, but it is nickel plated. OHT indicated that these coolers are plated by OHT, so they can be procured without plating. There were some concerns about the copper in these coolers leaching into the oil, but this was primarily a concern in the Sequence III due to much higher oil temperatures. In addition, studies by some suppliers indicated that copper had little or no effect on severity. It was noted that the coolers that are currently used in the IVA are copper brazed and are not nickel plated. The panel approved a motion by Bill Buscher and seconded by Jerry Brys to allow the use of oil cooler, part number OHTKA24-006-1 with adapter OHTKA24-005-1 as an acceptable replacement for the Nissan Cooler, providing an acceptable calibration test has been conducted in the laboratory using this cooler. Once a laboratory switches to this cooler it must continue to use this cooler for subsequent engine installations. This motion was approved by twelve members with one member abstaining. Distributors are currently being refurbished with no issues noted at this time. There are a number of engines and heads that have runs remaining on them based on the current procedure, which could be reinstalled. In previous discussions, it was determined that there is no issue with blowby and oil consumption up to 50 runs on an engine. With that, the panel approved a motion by Al Lopez and seconded by Jerry Brys to increase the number of runs allowed on an engine to 48 and on cylinder heads to 24 runs. This motion was approved by twelve members with one member abstaining. Additional hardware that is no longer available included throttle bodies, exhaust manifolds and intake manifolds. Some labs have been obtaining this hardware from salvage yards. It is believed that throttle bodies can be refurbished and an Action item was assigned to the panel to define a procedure for reworking throttle bodies. Though previously discussed, Jerry Brys was given the action item to provide the source for remanufactured Engine control modules. Labs are also to check their inventory for damaged harnesses that can be shipped to OHT for rework. A copy of Bill's hardware report is included as attachment 5.

Reference Oil Review

Twenty five test targets were reviewed. These data are included in attachment 6. There being almost no difference between the twenty five test and fifteen test means and standard deviations, the panel decided to take no action at this time and to assign an action item to Rich Grundza to fix targets when thirty tests are obtained. Bill Buscher again reiterated the need for an oil in the 50 to 60 micron range and asked panel members to check with their companies and suppliers to see if one could be made available.

Driveline Dynamics Task Force.

Eric Liu presented the work he has done with regard to analyzing driveline vibrations, included as attachment 7. He noted that there is a difference between damped and solid shafts and this difference alters the natural frequency of the driveline. Driveline length can also alter the driveline frequency. Eric intends to attempt to correlate vibration to contact temperature and would like to incorporate data from the other labs. He intends to provide an update for the next meeting.

Test Hardware Modifications

In line with the previous discussions the panel approved a motion by Rich Grundza, seconded by Jason Bowden to not allow modification or alteration of test hardware without the direction of the surveillance panel. This motion was approved unanimously.

Sequence IVB Update

Bill reviewed a presentation from Terri Crosby of Toyota regarding IVB development. Southwest has two stands installed, one stand operational and the second needing a wiring harness. The engine is a four valve per cylinder, four cylinder engine and currently is using pump fuel. A laser mike will be needed for cam measurement. Bell housings are a special item and need to be procured from Toyota. OHT is developing a

jacketed valve cover and also is modifying a front cover to facilitate cam removal and installation. Other labs were asked about their ability to install stands and Afton was unsure whether they would be installing a stand. Lubrizol and Ashland will be installing stands, but probably wouldn't be able to participate in a matrix.

Next meeting.

A conference call or face to face meeting will be undertaken shortly after the minutes are issued with the Southwest report tests regarding the regrinding on convexity of some cam lots.

A copy of the motions and action items from this meeting is included as 8.

With a motion to adjourn from Bill and a second from Rich, the meeting was adjourned at 5:45 PM.

Attachment 1

Sequence IVA Surveillance Panel

San Antonio, TX
Southwest Research Institute, Building 209
January 24, 2013
9:00 a.m. - 5:00 p.m.

A G E N D A

1.	Chairman comments	
2.	Attendance sign-in sheet distribution	
3.	Membership changes	
4.	Motion and Action recorders	
5.	Approval of minutes for 7/12/2012	All
6.	Action item review	Buscher
7.	Fuel supplier report – KA24E Green Fuel • Any issues with supply through 2016?	Carter

8.	Test availability and hardware status
	• Review latest IVA hardware survey results
	• Review severity of remaining camshaft batches
	• Review hardware shortages
	  • Test kits
	  • Oil coolers
	  • Distributors
	  • Wiring harnesses
	  • Other?
	• Review of test unavailability estimates
	• Update on additional industry hardware order from Nissan
		Buscher

9.	Develop plan to sustain test through 2016 • Redistribution of hardware between labs? • Correction factors applied to mild camshaft batches? • OHT to manufacture camshafts if Nissan	All

cannot offer an additional industry hardware order?
    - Reusing rocker arms and rocker shafts with OHT manufactured camshafts?
- Use OHT IIIF/IIIG nickel plated oil cooler as replacement for Nissan oil cooler?
    - An adapter would be necessary (SwRI has already designed one and could make a print available to OHT).
- Use Nissan or aftermarket distributor caps and rotors to rebuild distributors. This is already being done at some labs, with Nissan parts.
- If labs have been saving engine and cylinder head assemblies, the following can be considered:
    - Reinstall earlier engines and cylinder heads that have 12/16/20 and 6/8/10 runs to get the full 32 and 16 runs that are now allowed. This is already being done at some labs.
    - Rebuild used engine and cylinder head assemblies to allow for an additional 32 and 16 runs?
    - Increase the number of allowed runs beyond 32 and 16 runs?
- Acquire studs for cam caps and rocker covers to eliminate problems with threads in the aluminum cylinder heads?
- Use aftermarket gaskets and seals if Nissan components are no longer available?
- Acquire used components from salvage yards to replace worn components from test stand kits. This is already being done at some labs.
    - Need to locate components from 1994 – 1996 Nissan pickup trucks.
    - Refurbish some components, such as throttle bodies, if necessary.
- Repair damaged and currently unusable wiring harnesses?

10. Reference Oil Review — Grundza/ Buscher
    - RO 1006-2 target status

- New RO status

11.	Update on driveline dynamics task force	Liu
12.	Update on Sequence IVB test development	Kowalski/ Buscher
13.	Review Scope & Objectives	Buscher
14.	Old business	
15.	New business	
16.	Next meeting	
17.	Tour of Sequence IVB test stands	All
18.	Adjourn	

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ASTM IVA SURVEILLANCE PANEL

January 24, 2013

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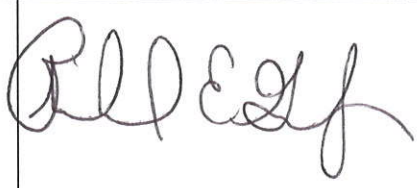
Grundza, Rich	ASTM Test Monitoring Center 6555 Penn Avenue Pittsburgh, PA 15206 Phone No.: 412-365-1031 Fax No.: 412-365-1047 Email: reg@astmtmc.cmu.edu	
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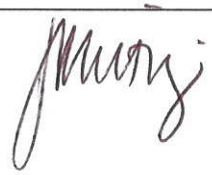
Martinez, Jo	Chevron Oronite Company LLC 100 Chevron Way, 60-1211 P.O. Box 1627 Richmond, CA 94802-0627 Phone No.: 510-242-5563 Fax No.: 510-242-1930 Email: jogm@chevrontexaco.com	
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	Phone No.: Fax No.: Email:	
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PRODUCT: KA24E TEST FUEL **Batch No.:**
HALTERMANN **TMO No.:**
PRODUCT CODE: HF0008 **Tank No.:**
Date:

TEST	METHOD	UNITS	SPECIFICATIONS MIN	TARGET	MAX
Distillation - IBP	ASTM D86	°F	75		95
5%		°F			
10%		°F	120		135
20%		°F			
30%		°F			
40%		°F			
50%		°F	200		230
60%		°F			
70%		°F			
80%		°F			
90%		°F	300		325
95%		°F			
Distillation - EP		°F	385		415
Recovery		vol %		Report	
Residue		vol %		Report	
Loss		vol %		Report	
Gravity	ASTM D4052	°API	58.7		61.2
Density	ASTM D4052	kg/l	0.734		0.744
Reid Vapor Pressure	ASTM D5191	psi	8.8		9.2
Carbon	ASTM E191	wt fraction	0.858		0.8667
Carbon	ASTM D3343	wt fraction		Report	
Sulfur	ASTM D2622	wt %	0.01		0.04
Lead	ASTM D3237	g/gal			0.05
Oxygen	ASTM D4815	wt %			0.2
Composition, aromatics	ASTM D1319	vol %			35
Composition, olefins	ASTM D1319	vol %	5		10
Composition, saturates	ASTM D1319	vol %		Report	
Oxidation Stability	ASTM D525	minutes	1440		
Copper Corrosion	ASTM D130				1
Gum content, washed	ASTM D381	mg/100ml			5
Research Octane Number	ASTM D2699		96		97.5
Motor Octane Number	ASTM D2700			Report	
R+M/2	D2699/2700			Report	
Sensitivity	D2699/2700		7.5		
Net Heat of Combustion	ASTM D240	btu/lb		Report	
Color	Visual			Green	

AL1221GP03	AJ1521GP01	AF2621GP02	AE1521GP01	AB0921GP05
802120	802000	801912	801852	903591
52	235	235	234	662
1/3/2013	10/18/2012	6/26/2012	5/22/2012	2/17/2012
RESULTS	RESULTS	RESULTS	RESULTS	RESULTS
91	91	86	86	90
114	113	111	111	114
126	127	126	125	125
145	147	148	146	144
170	172	173	170	168
200	202	202	200	199
220	221	221	220	220
230	229	232	231	230
239	239	241	240	239
255	256	258	257	257
316	315	320	315	318
344	343	348	343	344
394	397	404	387	394
97.5	97.2	96.9	97.8	97.8
1	0.9	1.1	1.1	1.2
1.5	1.9	2	1.1	1
59.9	59.9	59.4	60	59.7
0.738	0.738	0.741	0.738	0.739
9	9.2	9	9.2	9.1
0.8622	0.8639	0.8626	0.8632	0.8627
0.8646	0.8643	0.8645	0.8644	0.865
0.01	0.02	0.02	0.02	0.02
None Detected	None Detected	None Detected	None Detected	None Detected
None Detected	None Detected	None Detected	None Detected	None Detected
28.4	27.8	27.8	27.9	28.8
6	5.8	5.9	5.7	6.2
65.6	66.3	66.3	66.4	65
1440+	1440+	1440+	1440+	1440+
1a	1a	1a	1a	1a
<0.5	<0.5	2	<0.5	<0.5
97.3	97.3	97.2	97.3	97.2
88.2	87.8	88.1	88.2	88.2
92.8	92.6	92.6	92.8	92.7
9.1	9.5	9.1	9.1	9
18308	18322	18366	18370	18344
Green	Green	Green	Green	Green

Attachment 5

Sequence IVA

Test Hardware Report

Prepared by:
William A. Buscher III

January 24, 2013
San Antonio, Texas

Test Hardware Report

- Hardware Status:
  - All previous Nissan hardware orders have been completed
  - Industry currently using mixture of 2007 and 2009 test kits
  - Test hardware NOT secured through 2016
  - Usage rates in 2010, 2011 and 2012 have been much higher than projected when the final hardware order was placed back in 2009
    - Candidate testing doubled in last 6 months (N = 99 vs. 53)

Test Hardware Report

- Hardware Status:
  - Based on estimated usage rates and quantities currently on-hand at the laboratories, some labs will deplete hardware by late 2013 and industry will deplete hardware by mid 2014

Lab	A	B	C	F
Estimated Hardware Depletion	Late 2013	Mid 2014	N/A	Late 2013
Estimated Additional Runs Needed	352	148	N/A	70

  - Estimate hardware needed for ≈ 550 – 600 tests to be secured through 2016

Test Hardware Report

- Hardware Status:
  - SP chair has been in communication with Nissan discussing another Sequence IVA hardware solicitation to be offered to the ASTM test labs
  - Nissan indicated that the Sequence IVA Test Kit, p/n 13000-40F85 (camshafts, rocker arms, rocker shafts, oil filters, spark plugs), Engine Valve Regrind Kit p/n A1042-10C2K (gasket kit) and Assembled Cylinder Head p/n A1040-40F85 are out of production, but individual alternative components are available

Test Hardware Report

SPPS	Parts number		Name	Availability		
96-1332	13000 40F85		Test Kit	NO		
Composition of "Test kit 13000 40F85"						
	Parts number		Parts name	riginal parts numbe	lternative part	QTY
	A3020 40P01	A302040P01	CAM SHAFT ASSY	13020 40F01		1
	13252 40F10	1325240F10	SHAFT ROCKER	13252 40F10	13252 40F1A	1
	13245 40F10	1324540F10	SHAFT ROCKER	13245 40F10	13245 40F1A	1
	A3257 40F06	A325740F06	ROCKER VALVE	13257 40F06		4
	A3257 40F07	A325740F07	ROCKER VALVE	13257 40F07		4
	A3257 40F16	A325740F16	ROCKER VALVE	13257 40F16		2
	A3257 40F17	A325740F17	ROCKER VALVE	13257 40F17		2
	15208 H8904	15208H8904	FILTER ASSY OIL	15208 H8904	15208 H890C	3
	22401 30R15	2240130R15	PLUG SPARK	22401 30R15		4

Test Hardware Report

SPPS		Parts number	Name	Availability				
07-1123	A1042 10C2K		Gasket Kit	OK				
Composition of "Gasket kit A1042 10C2K"								
		Parts number	Parts name	Original parts number		Alternative parts		QTY
		11044 40F00	GSKT-CYL HEAD	11044 40F00	1104440F00	11044 40F10	1104440F10	1
		13207 D0111	SEAL-OIL,VALVE	13207 D0111	13207D0111	13207 53F00	1320753F00	2
		13207 42L00	SEAL-OIL,VALVE	13207 42L00	1320742L00			1
		13270 F4000	GSKT-ROCKER COVER	13270 F4000	13270F4000			1
		14035 40F10	GSKT MANIFOLD	14035 40F10	1403540F10			1
		14036 40F00	GSKT-EXH MAINF	14036 40F00	1403640F00			2

Test Hardware Report

SPPS	Parts number	Name		Availability	
97-0736	A1040 40F80	Head Assy		NO	
Composition of "Head assy A1040 40F80"					
	Parts number	Parts name	Original parts number	Alternative parts	QTY
	A1040 40F11	HEAD ASSY	A1040 40F11	11040 40F11	1
	13201 40F00	VALVE-INT	13201 40F00		8
	13202 40F01	VALVE-EXH	13202 40F01		4
	13205 40F00	SEAT VALVE SPRING,OUTER	13205 40F00		8
	13205 40F10	SEAT VALVE SPRING,OUTER	13205 40F10	13205 40F1A	4
	13206 40F01	SEAT VALVE SPRING,INNER	13206 40F01	13206 40F0A	8
	13206 40F10	SEAT VALVE SPRING,INNER	13206 40F10	13206 40F1A	4
	13209 40F00	RET-VALVE,SPR	13209 40F00		8
	13209 40F10	RET-VALVE,SPR	13209 40F10		4
	13210 40F00	COLLET-VALVE,SPR	13210 40F00		24
	13211 40F01	SPRING SET-VALVE,INT	13211 40F01 = 13203 40F01 + 13204 40F01		8
		SPRING -VALVE,INT	13203 40F01		8
		SPRING -VALVE,INT	13204 40F01		8
	13211 40F11	SPRING SET-VALVE,EXH	13211 40F11 = 13203 40F11 + 13204 40F11		4
		SPRING -VALVE,EXH	13203 40F11		4
		SPRING -VALVE,EXH	13204 40F11		4
	13207 53F00	SEAL-LIP, INT VALVE	13207 53F00	13207 D0111	8
	13207 40F00	SEAL-LIP, EXH VALVE	13207 40F00	13207 42L00	4

Test Hardware Report

- Hardware Status:
  - Nissan indicated that individual components listed in the previous slides can be made available in the quantities required, as indicated by the ASTM test labs
  - Nissan is working on pricing and timing
  - Takumaru Sagawa of Nissan Japan will be meeting with the SP chair on Monday, 2/4/13, to further discuss Sequence IVA hardware supply

Test Hardware Report

- Other Hardware Concerns:
  - Oil coolers
  - Distributors
  - Wiring harnesses
  - ECUs
  - Other?

Test Hardware Report

- Severity of Remaining Camshaft Batches:
  - 070917A, referenced, 0.9 std. dev. severe
  - 080610, referenced, 0.5 std. dev. mild
  - 2009, referenced, 0.1 std. dev. severe
  - NK9X230, referenced, 1.2 std. dev. mild
  - NK04120, referenced, 0.2 std. dev. mild
  - NK05190, referenced, 1.3 std. dev. mild
  - NK05110, not referenced, 4.3 std. dev. Mild
    - 1 result, 1 lab
  - NK9Y100, not referenced, 2.9 std. dev. Mild
    - 3 results, 1 lab

Test Hardware Report

Camshaft Batch	Lab A	Lab B	Lab C	Lab F
070917A		X		X
080610	Depleted		X	
2009	Depleted	X		
NK9X230	X			
NK04120	X	X		
NK05190	X	X		
NK05110	X			
NK9Y100	X			

Sequence IVA 1006-2 Results

Sequence IV Surveillance Panel

January 24, 2013

Summary of Results

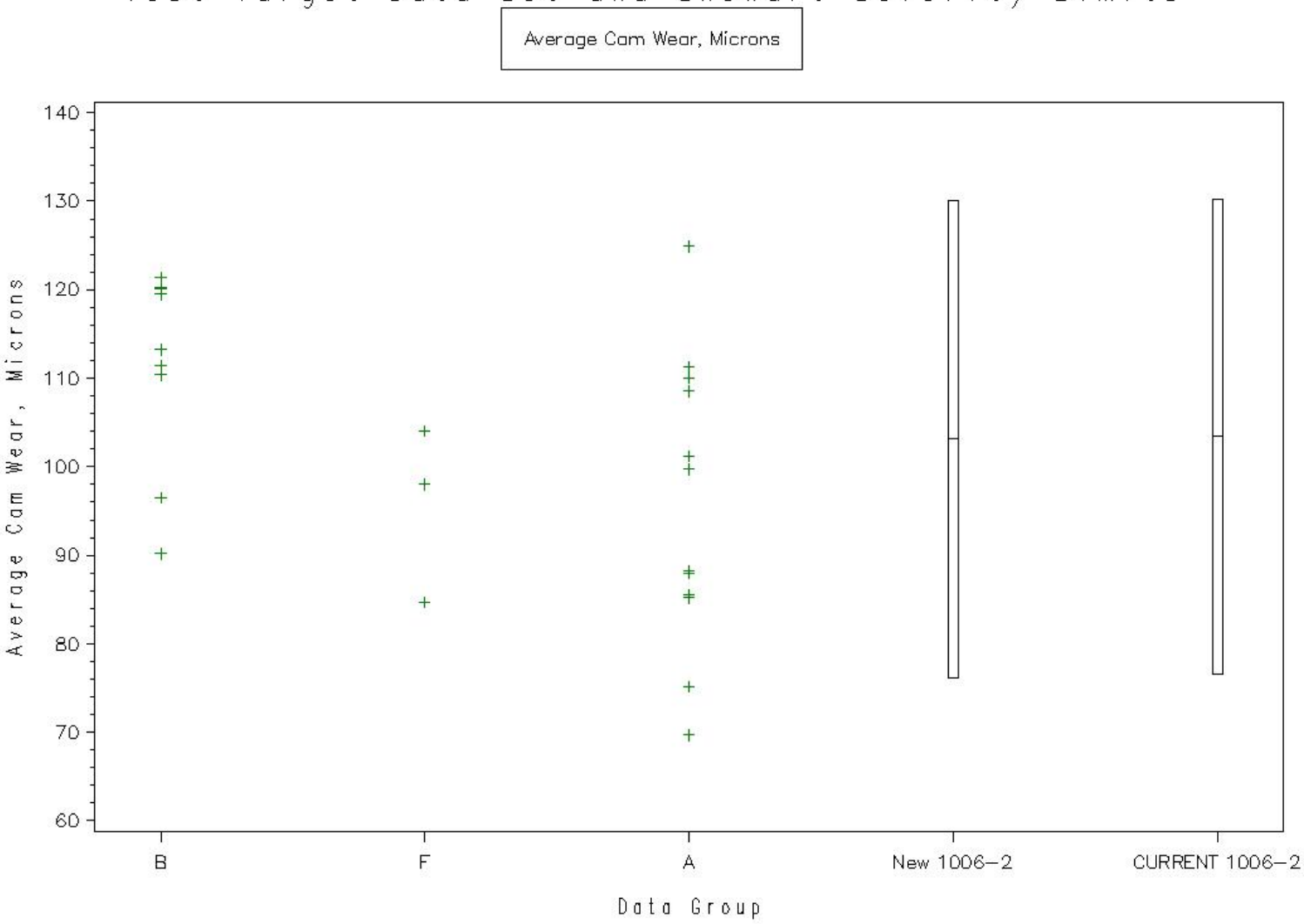
- 25 tests reported from three labs
- Little change in mean and standard deviation.
- Mean (n = 15) 103.68 Updated 103.16
- s (n = 15) 13.68 Updated 13.75
- Summary in next few slides

Summary of Results

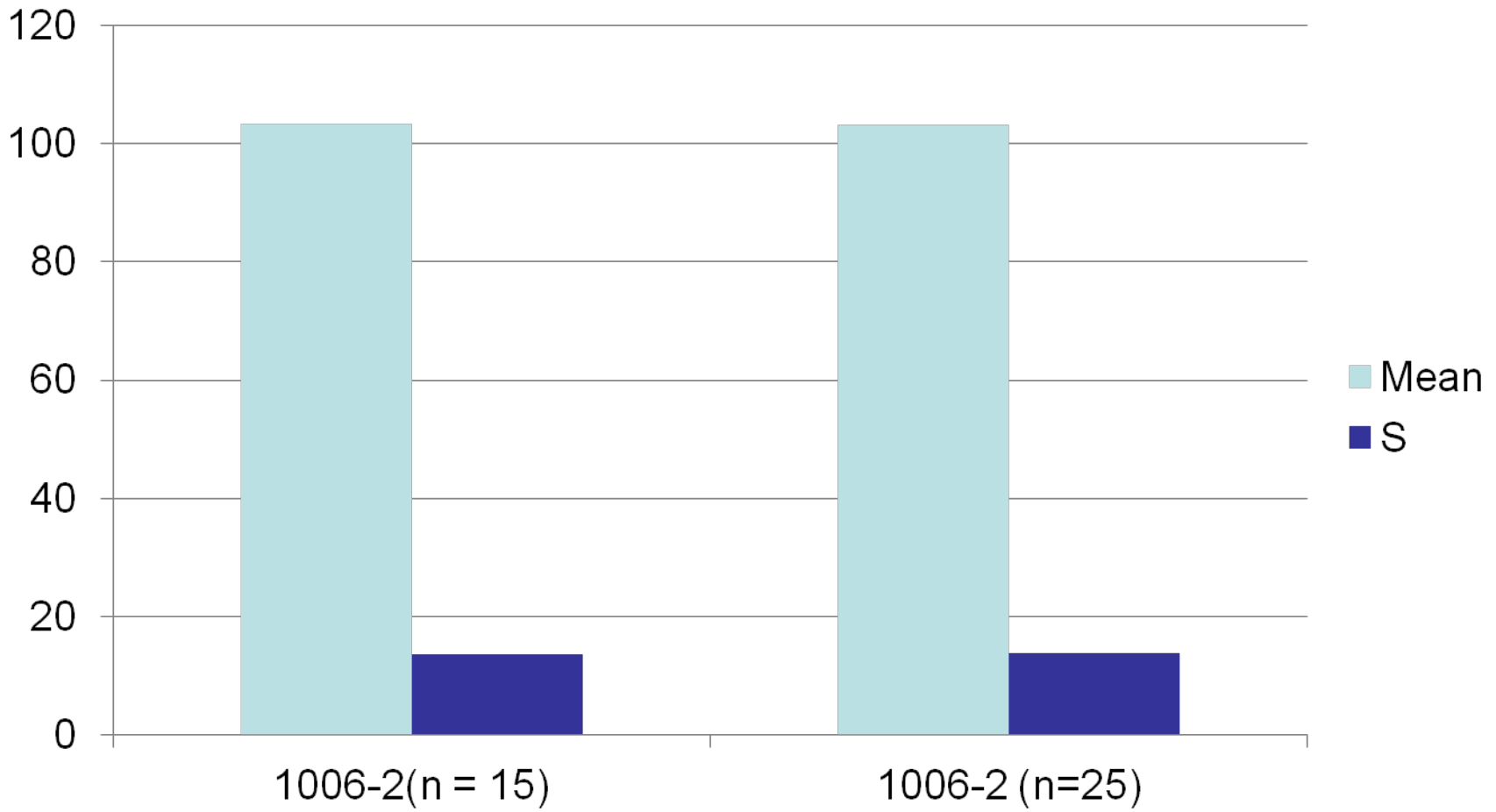
TESTKEY	LTMSLAB	LTMSDATE	IND	VAL	ACW	SA	Severity Adjusted Result
80991	B	20110809	1006-2	AG	120.24	0	120.24
84235	F	20111002	1006-2	AG	104.06	0	104.06
78808	A	20111009	1006-2	AG	101.24	0	101.24
84565	A	20111110	1006-2	AG	75.19	9.65	84.84
86108	B1	20120208	1006-2	AG	96.55	0	96.55
85064	A	20120213	1006-2	AC	85.48	16.567	102.047
86679	B1	20120226	1006-2	AC	111.47	0	111.47
86688	A	20120321	1006-2	AC	85.31	15.357	100.667
84326	F	20120328	1006-2	AC	98.05	0	98.05
86689	A	20120418	1006-2	AC	85.2	14.538	99.738
86690	A	20120423	1006-2	AC	110.04	0	110.04
87577	A	20120522	1006-2	AC	119.48	0	119.48
86680	B1	20120522	1006-2	AC	121.37	0	121.37
87578	A	20120616	1006-2	AC	111.32	0	111.32
87579	A	20120624	1006-2	AC	69.72	0	69.72
86868	F	20120711	1006-2	AC	84.72	0	84.72
88335	A	20120723	1006-2	AC	108.56	0	108.56
86871	B1	20120724	1006-2	AC	90.19	0	90.19
86682	B1	20120730	1006-2	AC	120.15	0	120.15
88336	A	20120808	1006-2	AC	124.93	0	124.93
88337	A	20120817	1006-2	AC	99.73	0	99.73
88807	B1	20121028	1006-2	AC	113.24	0	113.24
88806	B1	20121029	1006-2	AC	110.38	0	110.38
89508	A	20121202	1006-2	AC	88.28	0	88.28
91518	A	20121222	1006-2	AC	88.02	0	88.02

Figure 1

Sequence IVA (Reference Oil 1006-2)
Test Target Data Set and Shewart Severity Limits



Summary of Targets



A Program of ASTM International

DRIVELINE EFFECTS ON DYNAMIC TORSIONAL VIBRATION ON SEQUENCE IVA ENGINE STAND

Eric Liu, Research Engineer

Southwest Research Institute

January 24, 2013

Background
Sequence IVA Test Severity Issues

- Engine lubricant testing labs unable to discriminate between a severe wear lubricant and a mild wear lubricant
- Unable to produce severe wear on cam lobes
- Severity Task Force formed in 2008-2009

Hypothesis

- Demonstration showed different driveline configurations allowed labs to regain discrimination in cam lobe wear
- **Driveline of different *stiffness* changed the *torsional vibration dynamics* of the test stand**
- ***Torsional vibration dynamics* have a direct effect on *cam lobe wear***

Experimental Setup

Measuring Driveshaft Twist

Flywheel

120 teeth

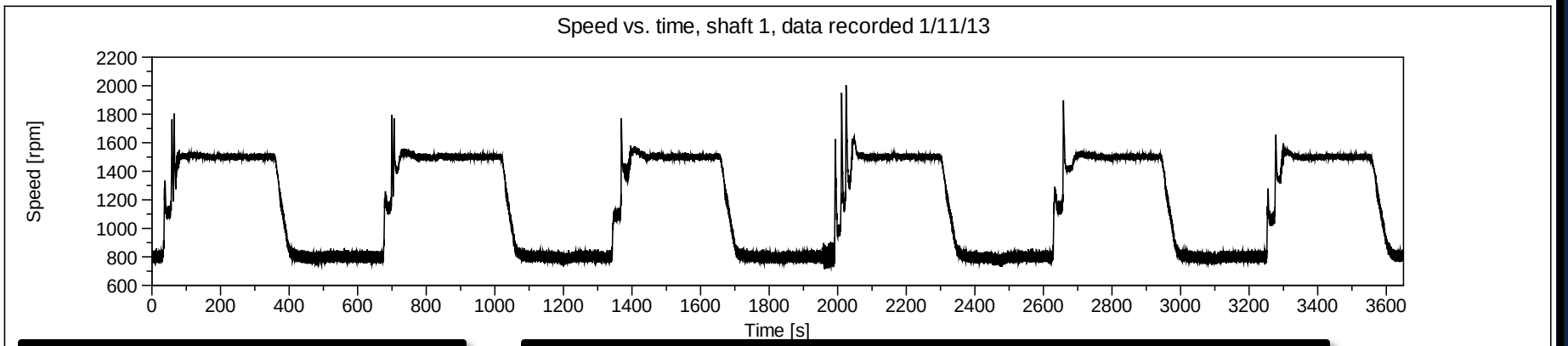
0.0524 rad/tooth

Dyno-Side Gear

160 teeth

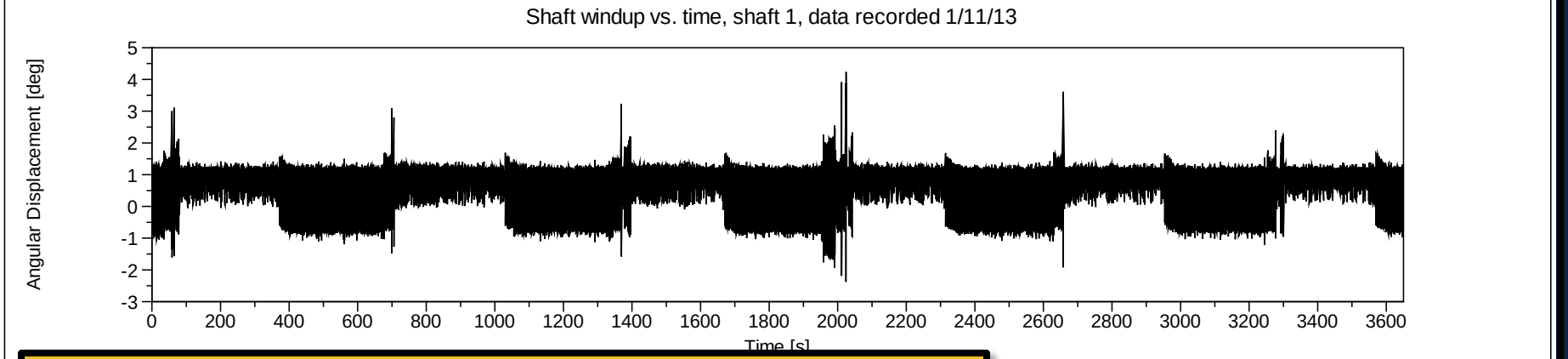
0.0393 rad/tooth

Calculating Shaft Wind-Up



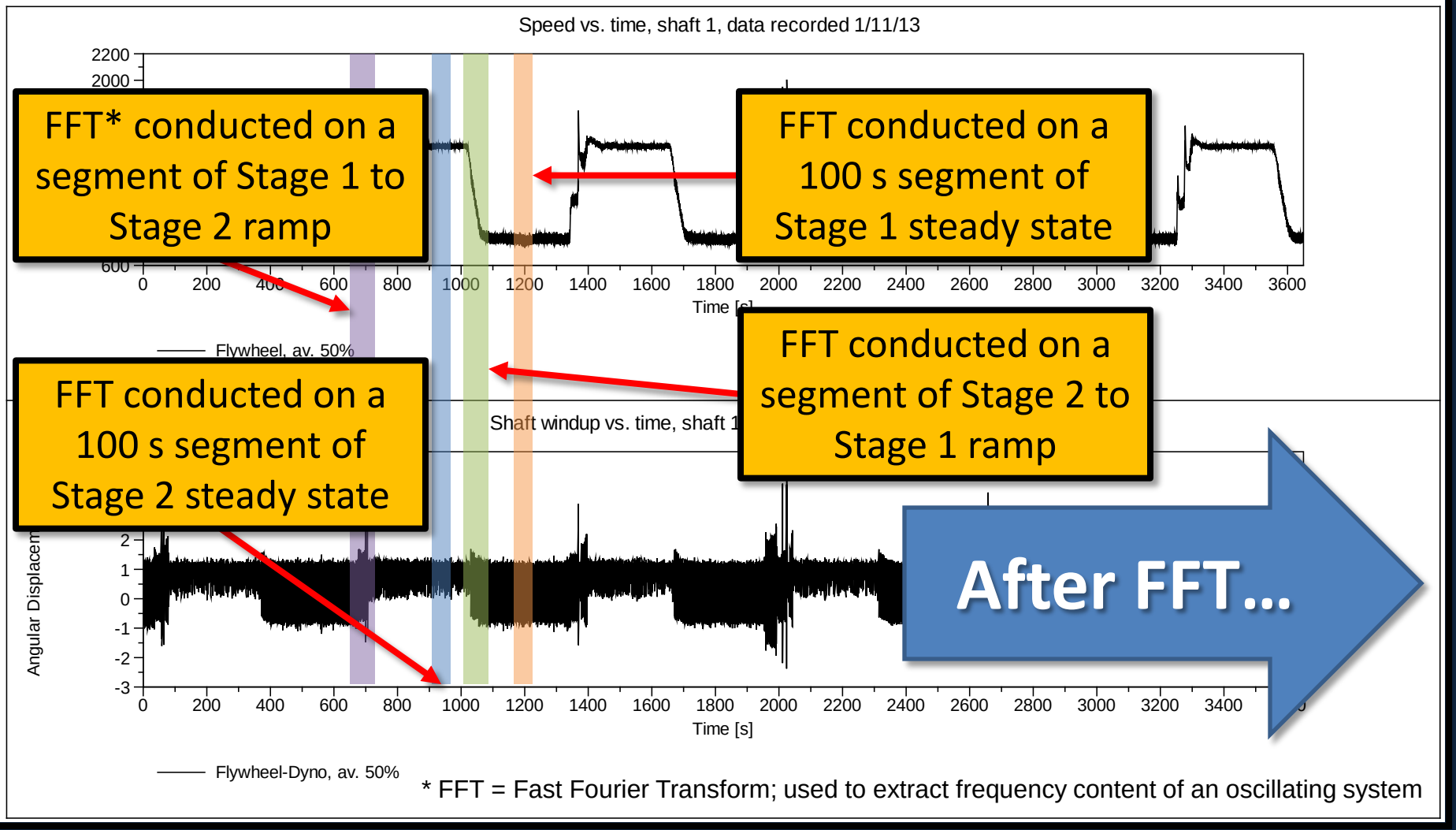
Flywheel Speed

Dynamometer hub speed is similar…



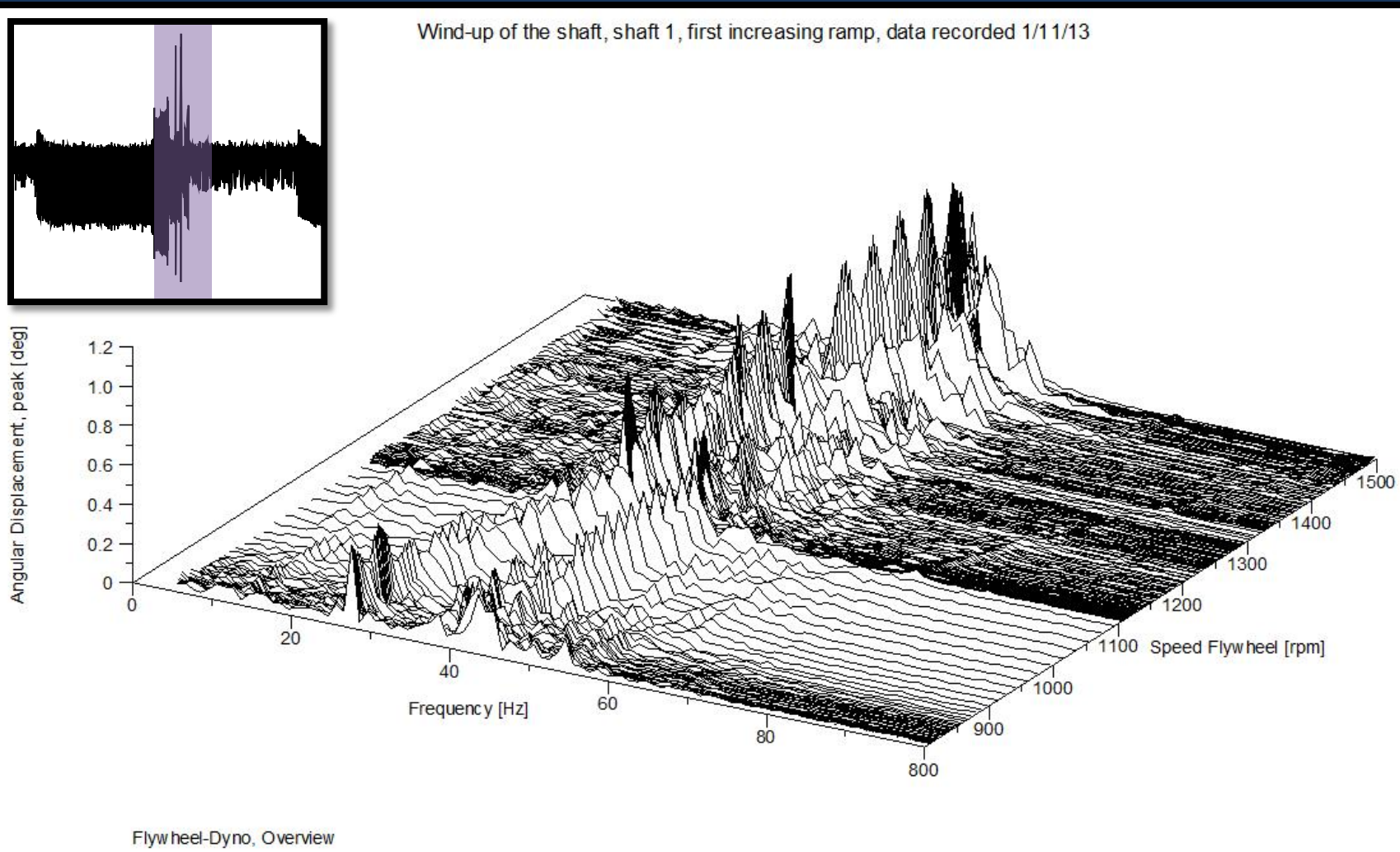
Flywheel Speed – Dynamometer Hub Speed

Obtaining Frequency Content

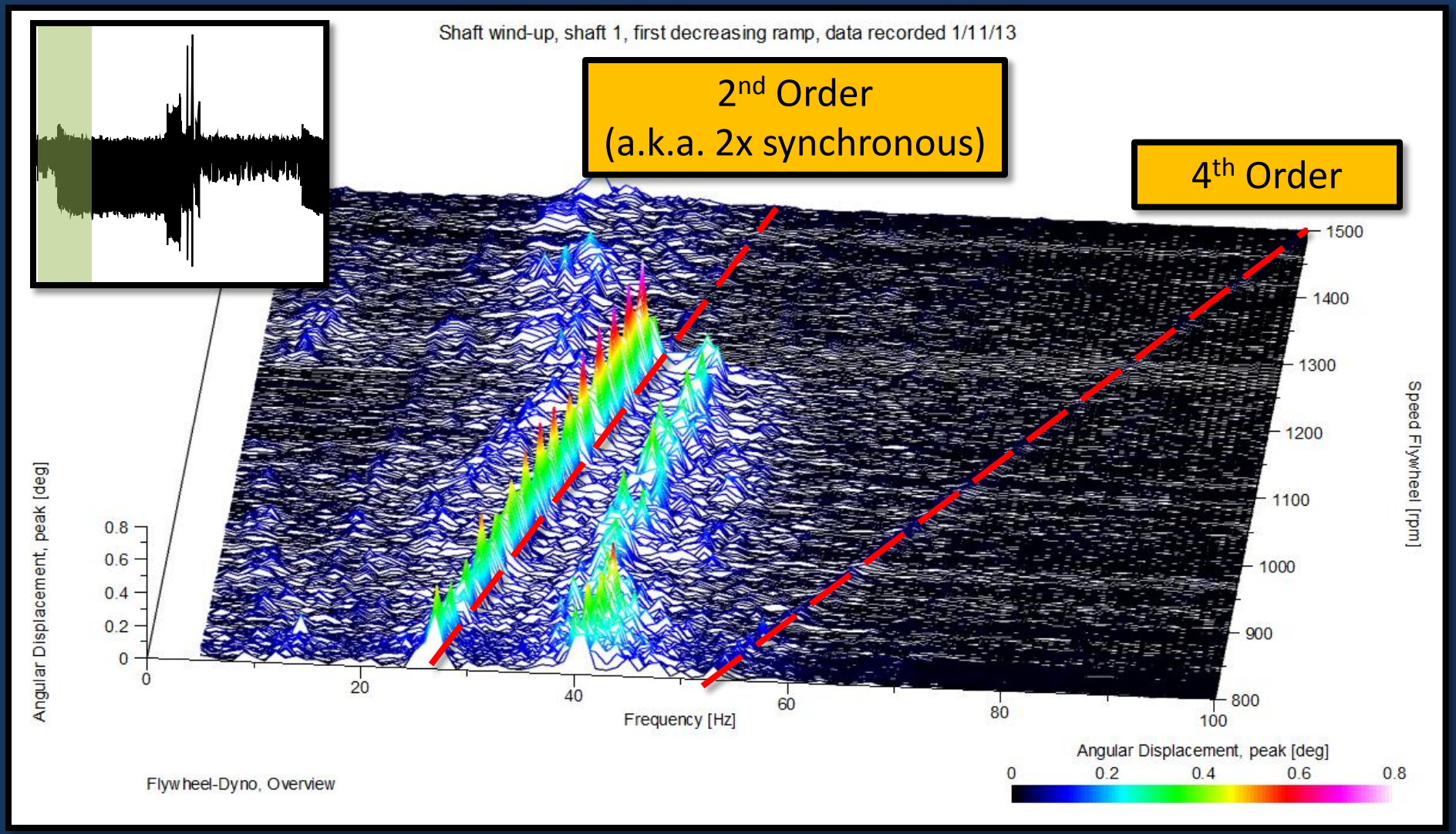


* FFT = Fast Fourier Transform; used to extract frequency content of an oscillating system

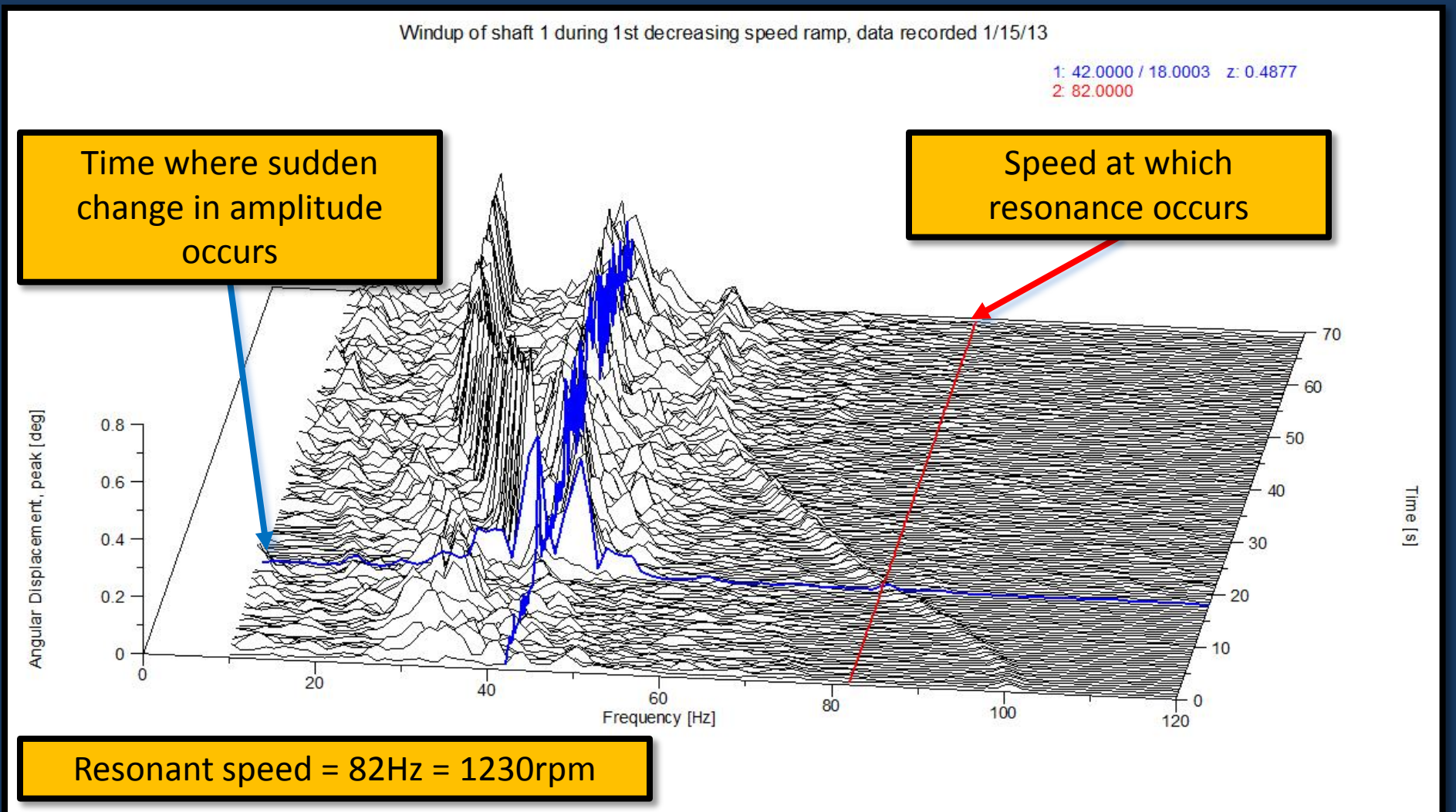
Frequency Content – 1 to 2 Ramp



Frequency Content – 2 to 1 Ramp



Natural Frequency on Ramps



Objective 1

- To quantify differences in torsional vibration dynamics in the engine test stand system between drivelines of different stiffnesses

Solid Shaft

Damped Shaft

Comparison of ω_n at Different Driveshaft Stiffness

Operation	Observed Resonant Frequency	
	Solid Shaft	Damped Shaft
1-2 Ramp	51Hz	39Hz
2-1 Ramp	44Hz	36Hz

- Natural frequency (ω_n) measured during the 1-2 ramp and the 2-1 ramps are not the same
- HOW?

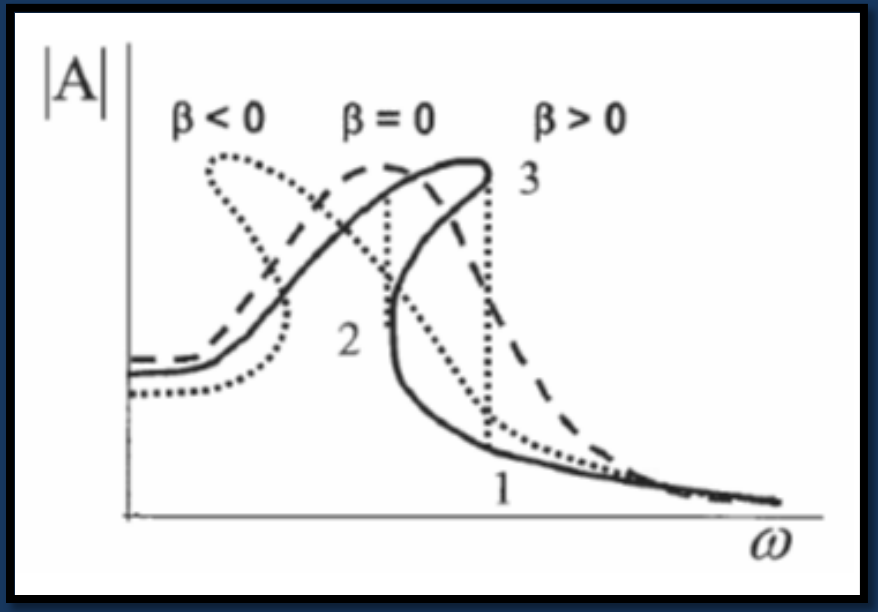
Comparison of ω_n at Different Driveshaft Stiffness

Operation	Observed Resonant Frequency	
	Solid Shaft	Damped Shaft
1-2 Ramp	51Hz	39Hz
2-1 Ramp	44Hz	36Hz

- **Supposition:** Lash in splines in the driveshaft result in a non-linear spring system
  - Initial conditions (twist angle) can change the frequency of oscillation
- Not as prominent in damped shaft
  - Stiffness of damped shaft is dominated by rubber

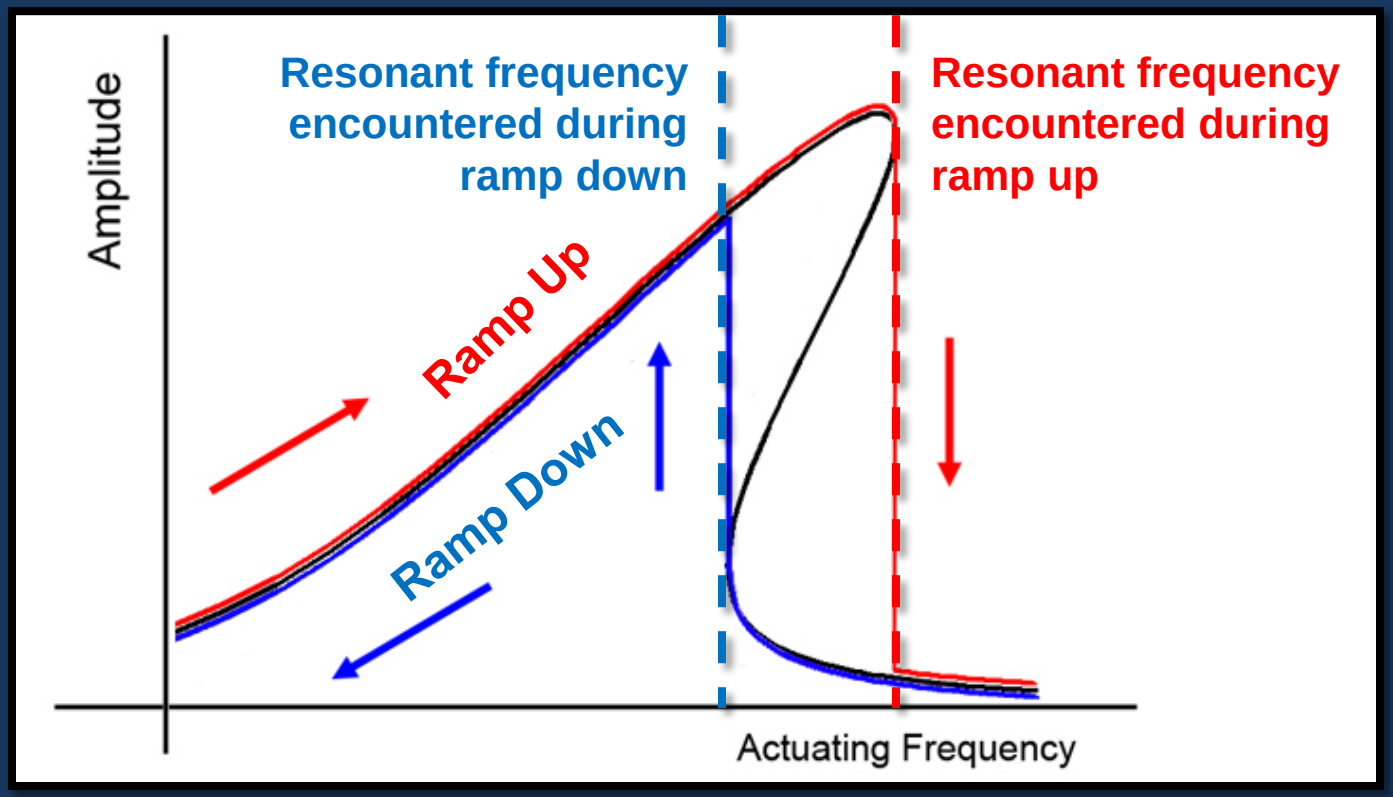
Non-Linear Spring System

- Duffing equation
  - $m\ddot{x} + c\dot{x} + \alpha x + \beta x^3 = \mathrm{F}\cos\omega t$
  - β = 0, linear spring
  - β > 0, hardening spring
  - β < 0, softening spring

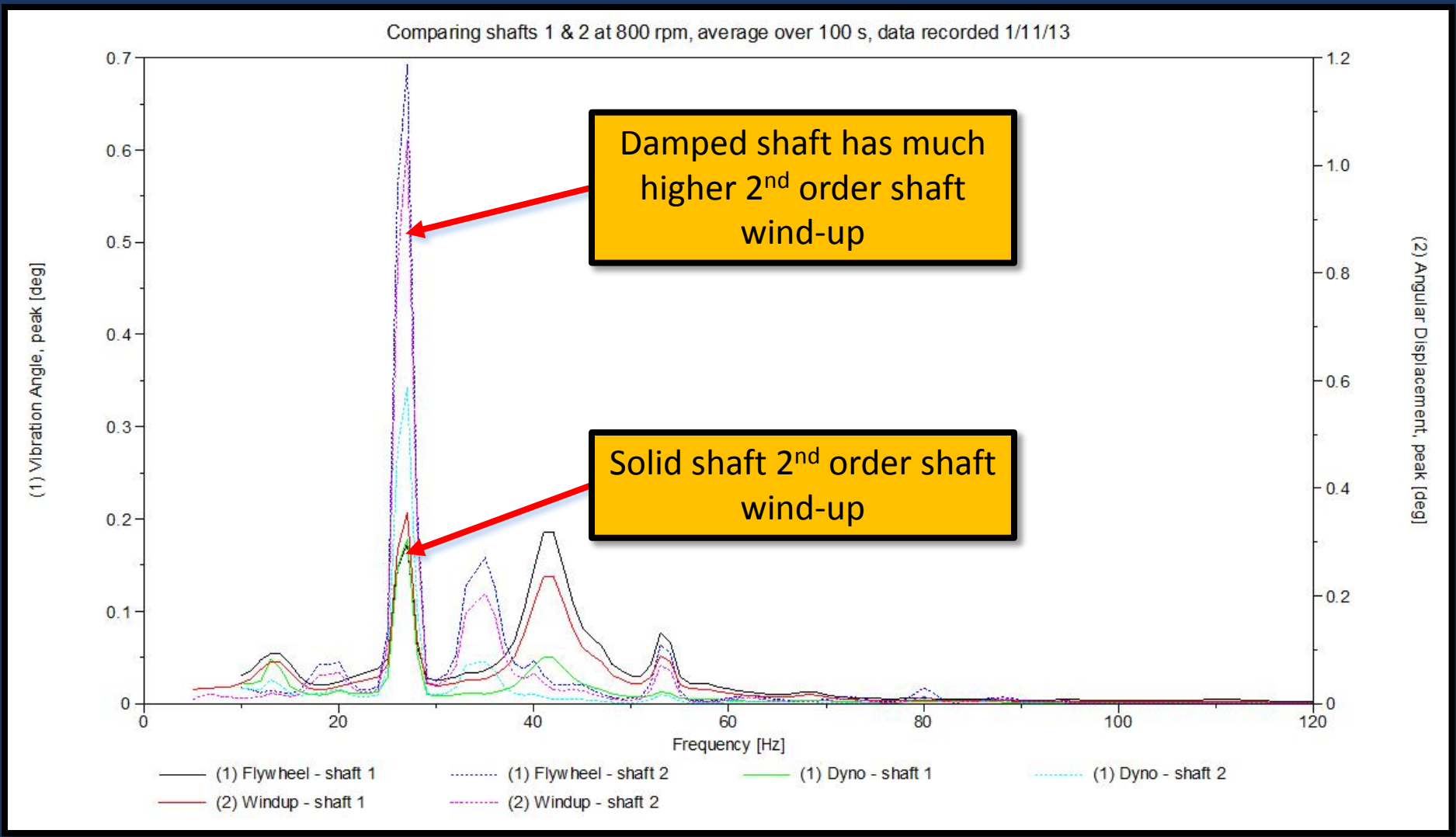


Hardening Spring System

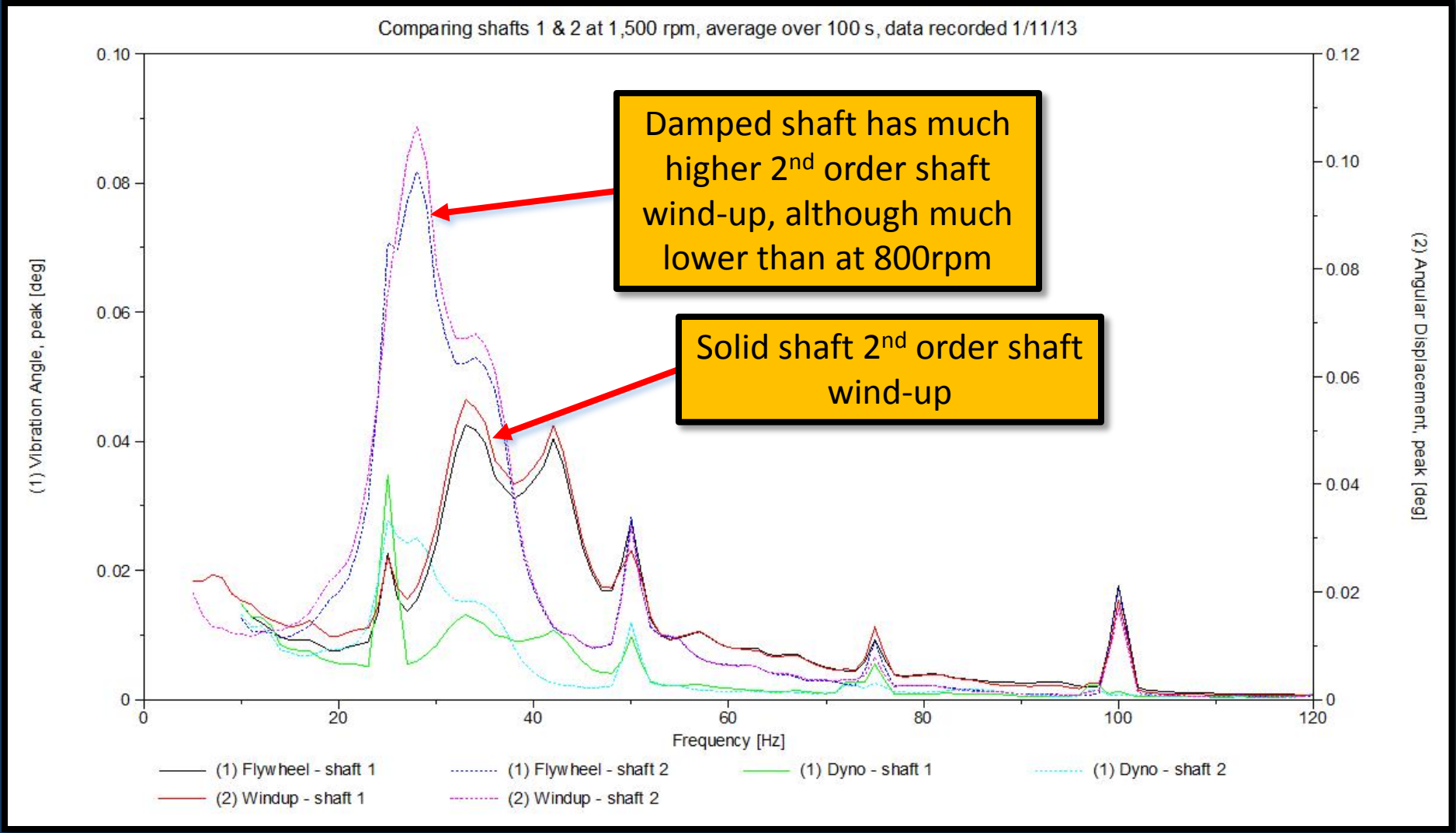
- Driveshaft vibration responses resemble hardening spring ($\beta > 0$)



Comparison of Driveshafts at 800rpm



Comparison of Driveshafts at 1500rpm



Objective 2

- To quantify differences in torsional vibration dynamics in the engine test stand system between drivelines of different lengths
- Driveshaft lengths: 34.5” vs. 20.5” (long vs. short)

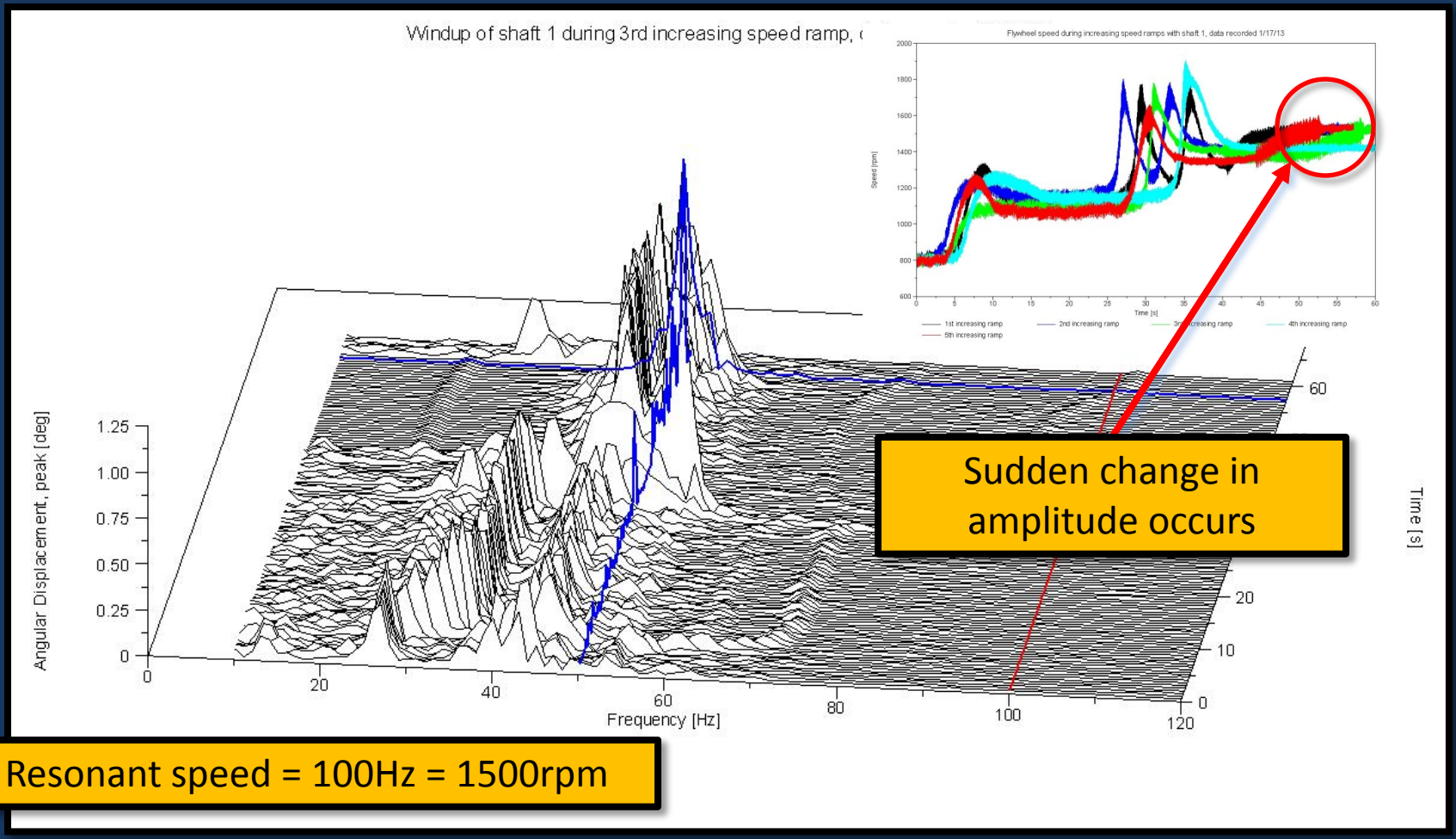
$$\omega_n = \sqrt{\frac{C}{J_{eq}}}$$

$$C = \frac{JG}{L}$$

$$J = \frac{\pi}{32}(D^4 - (D - 2t)^4)$$

Comparison of ω_n at Different Driveshaft Lengths on Ramp

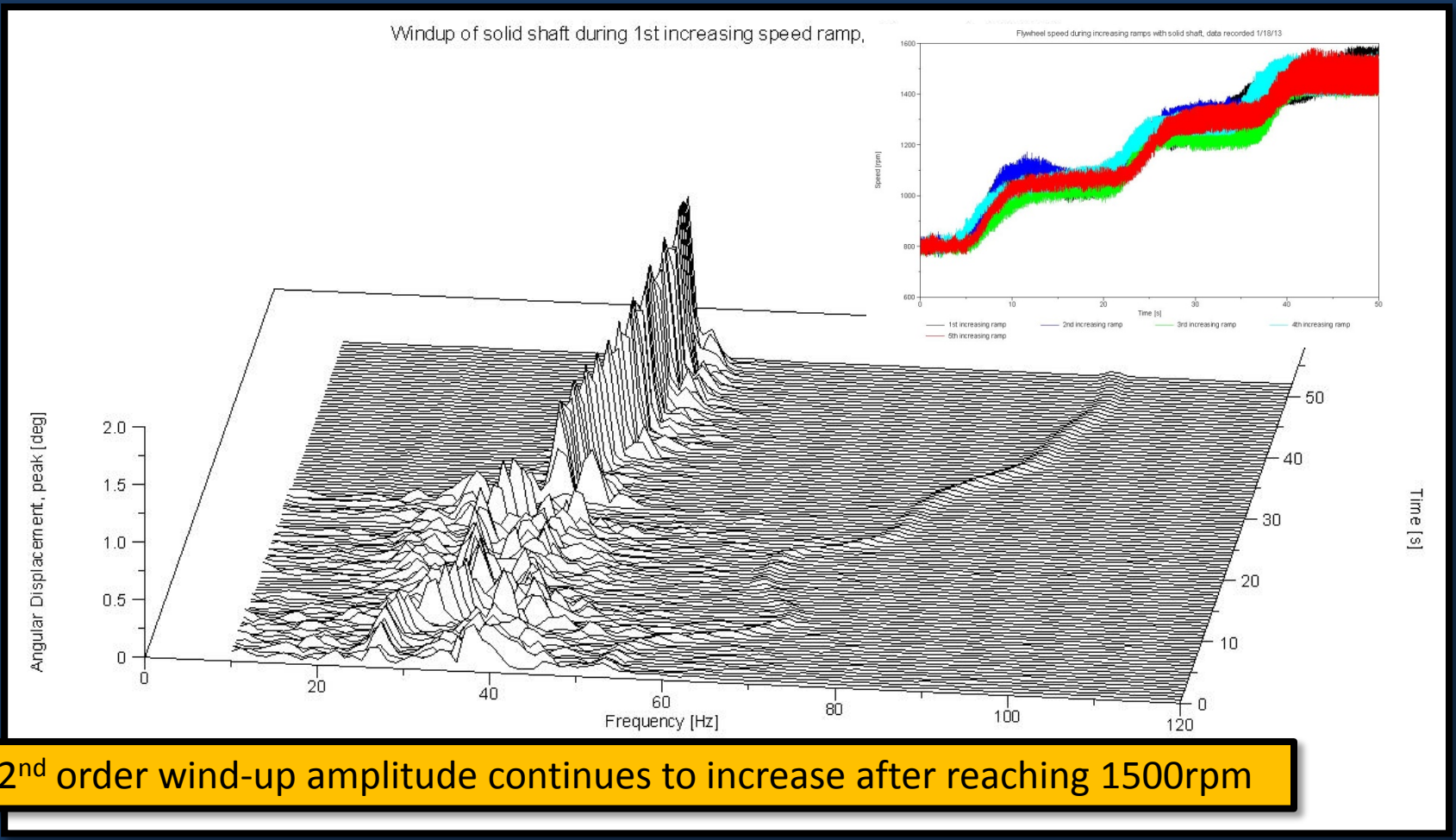
- 34.5” (Long) Solid Shaft



Resonant speed = 100Hz = 1500rpm

Comparison of ω_n at Different Driveshaft Lengths on Ramp

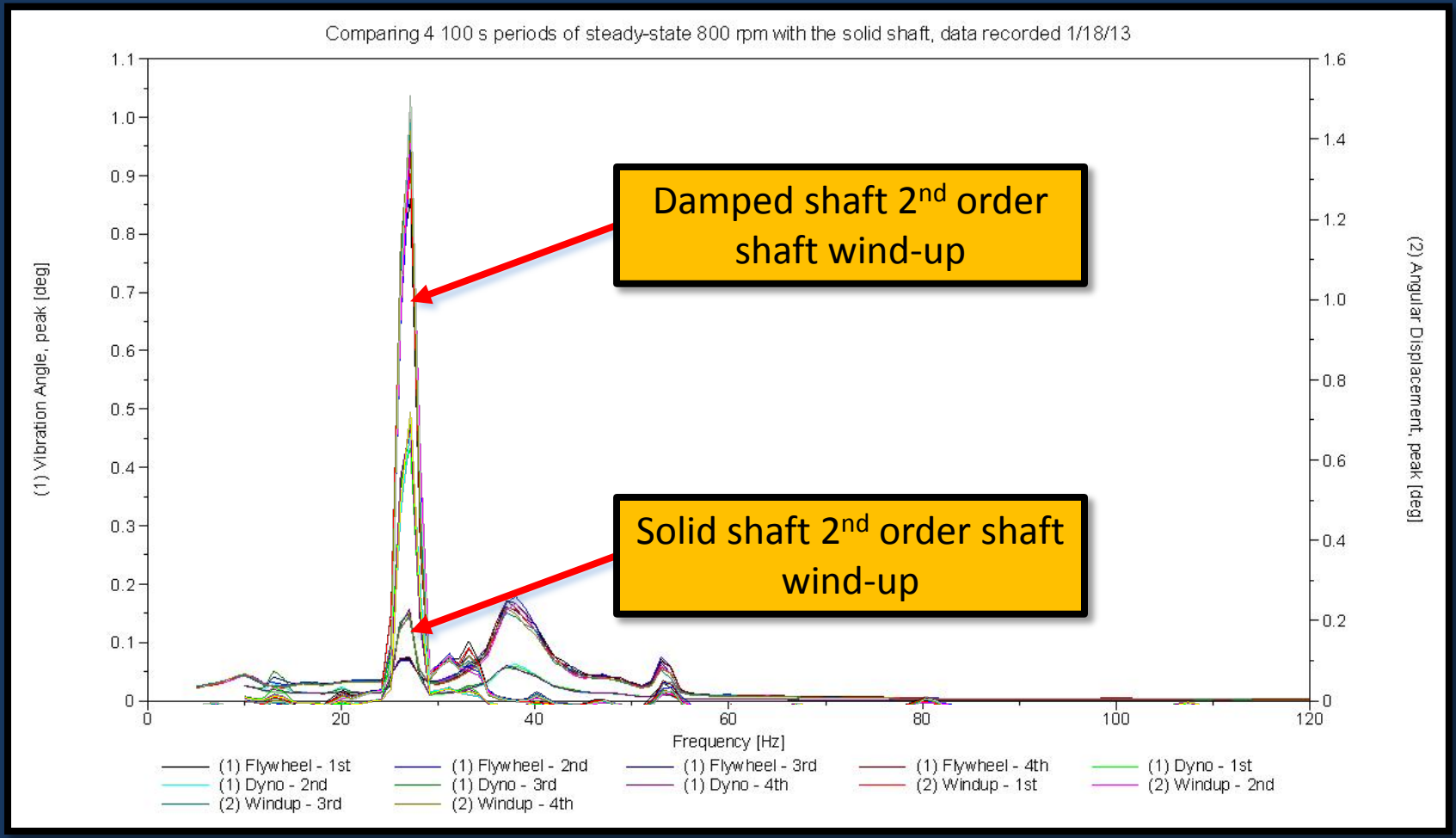
- 20.5” (Short) Solid Shaft



2nd order wind-up amplitude continues to increase after reaching 1500rpm

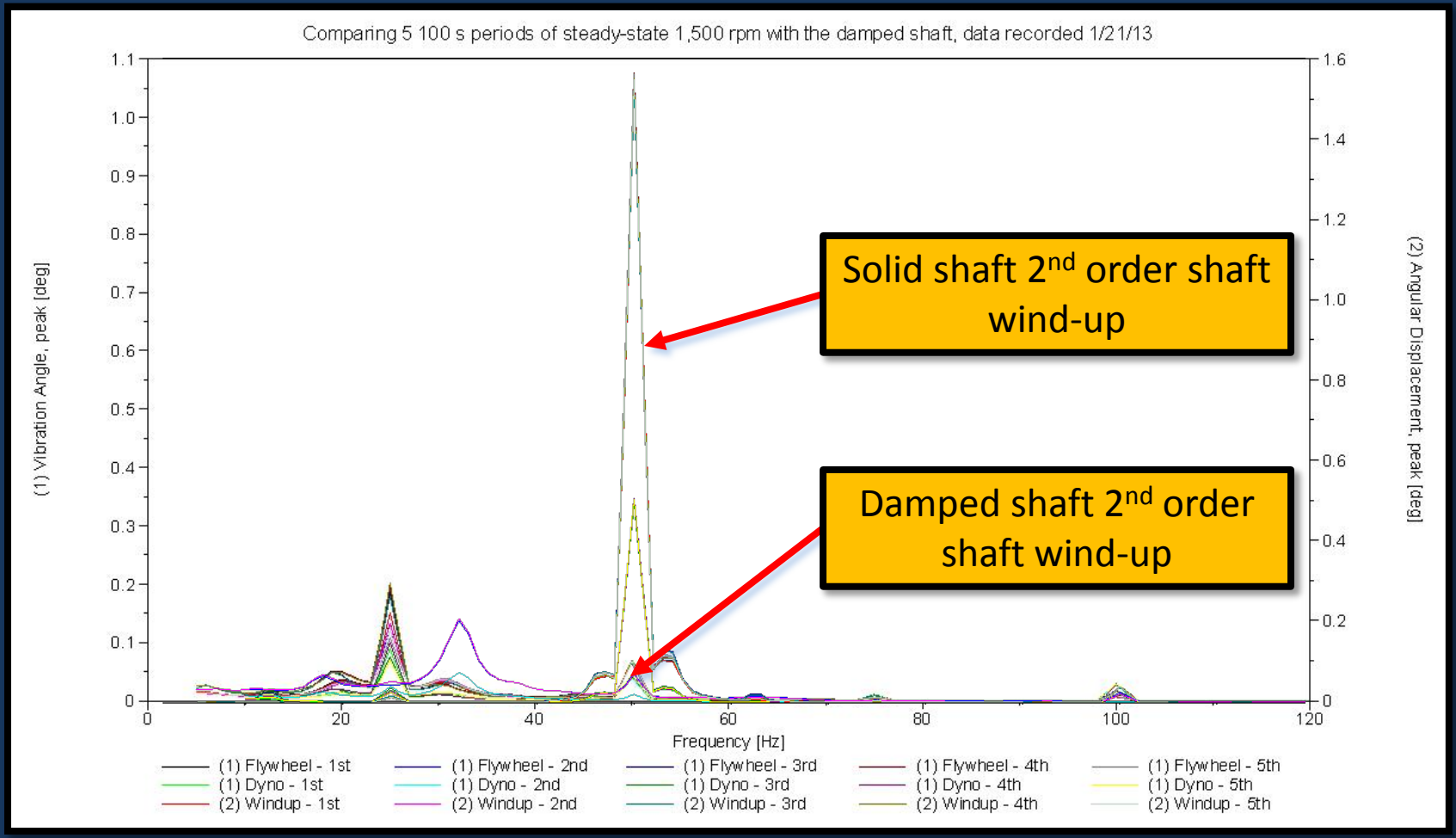
Comparison of ω_n at Different Driveshaft Lengths at 800rpm

- 20.5” Solid Shaft vs. Damped Shaft



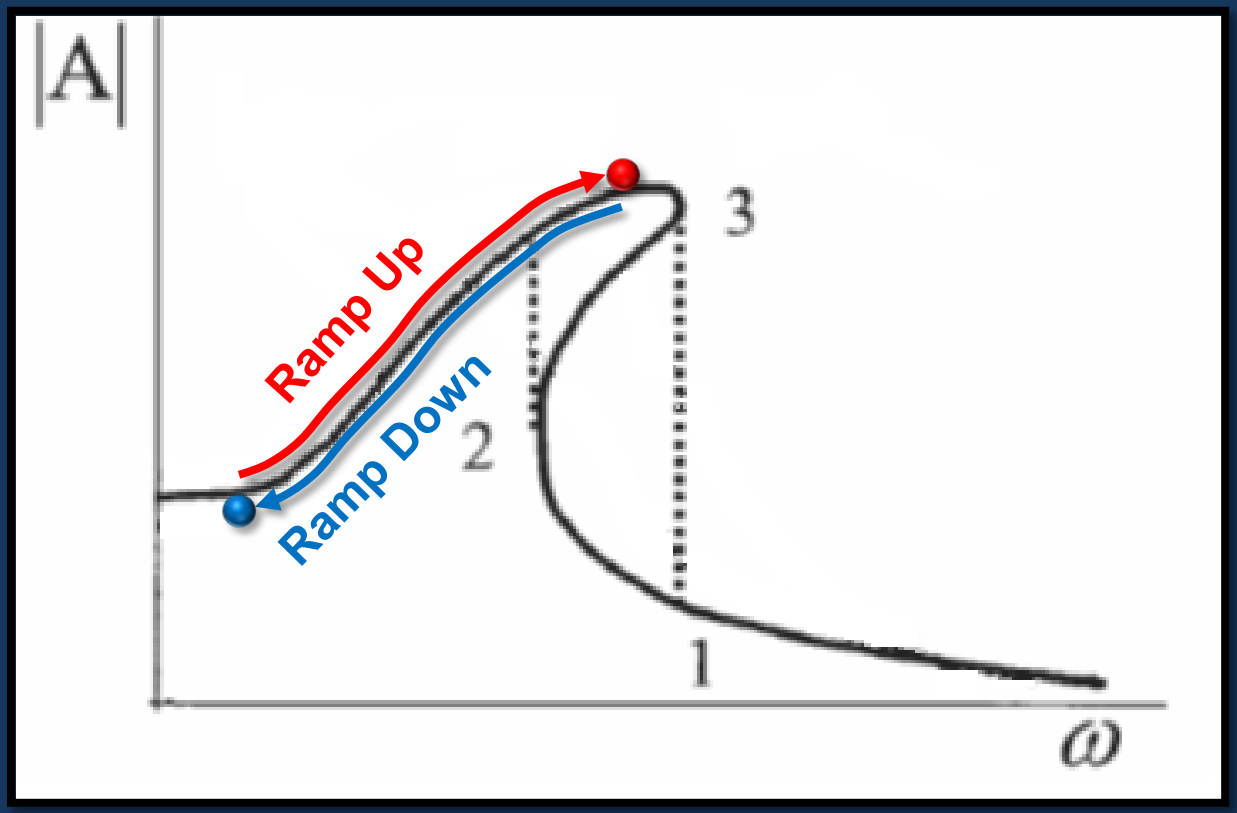
Comparison of ω_n at Different Driveshaft Lengths at 1500rpm

- 20.5” Solid Shaft vs. Damped Shaft



What is Happening with the Short Solid Shaft?

- Excitation frequency did not exceed natural frequency during ramp up (point 3)
- No Jump

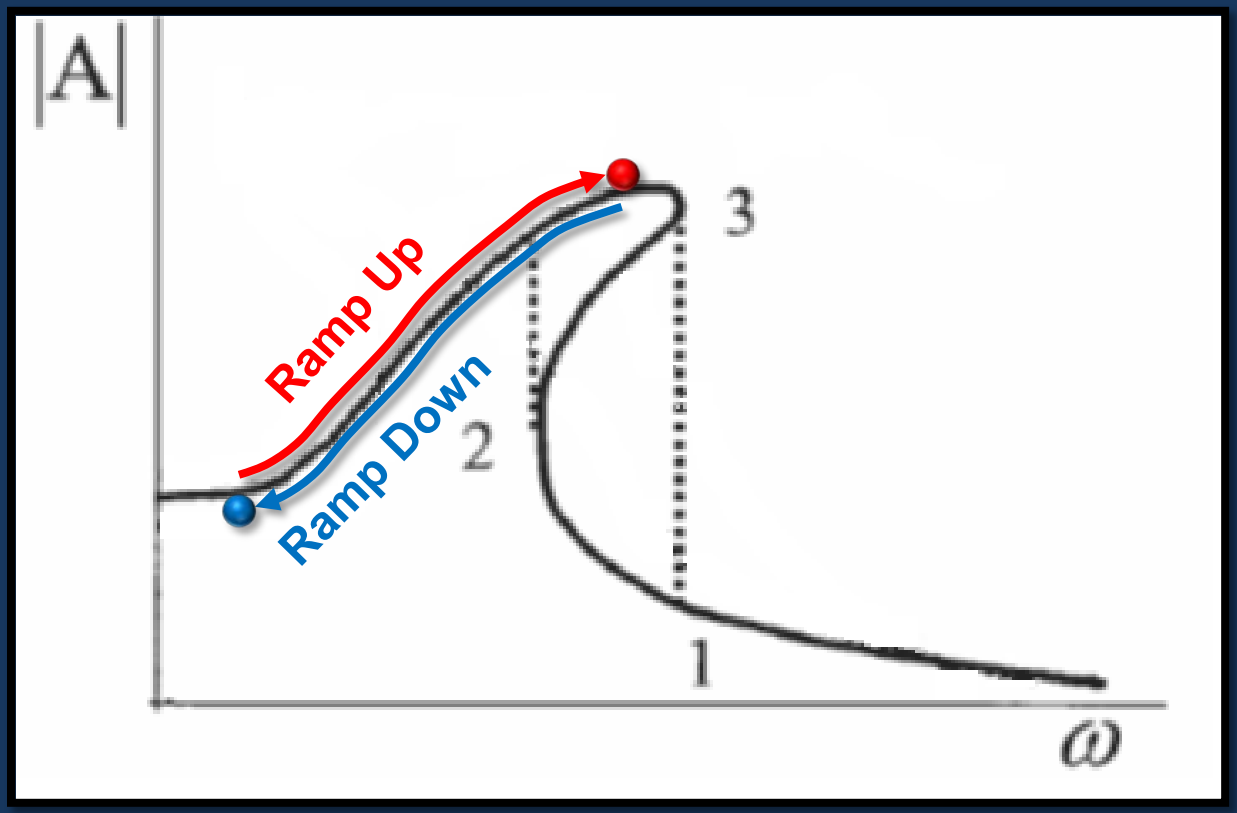


What is Happening with the Short Solid Shaft?

- Shift to higher natural frequency with shorter solid shaft

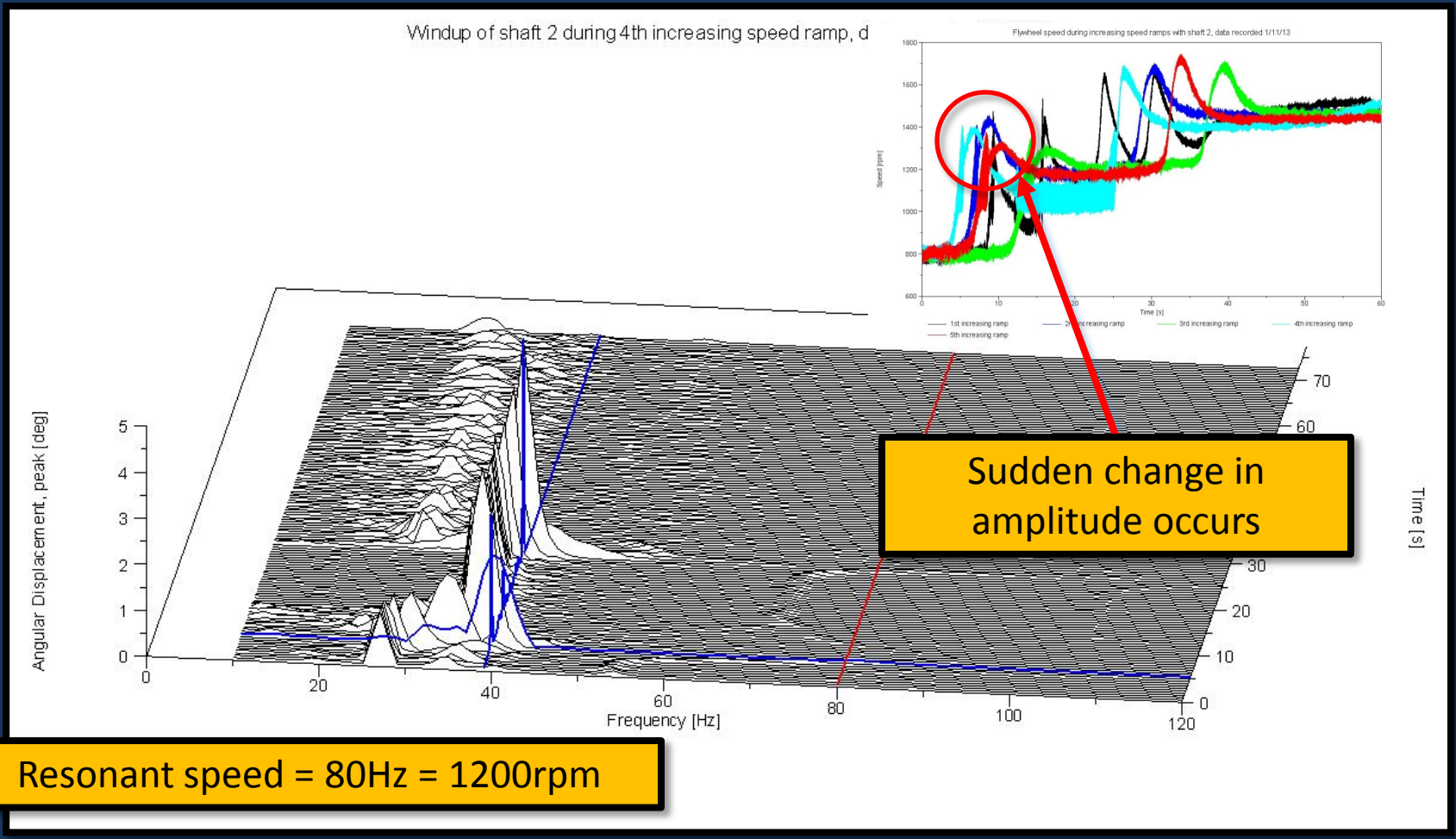
$$C = \frac{JG}{L}$$

$$\omega_n = \sqrt{\frac{C}{J_{eq}}}$$



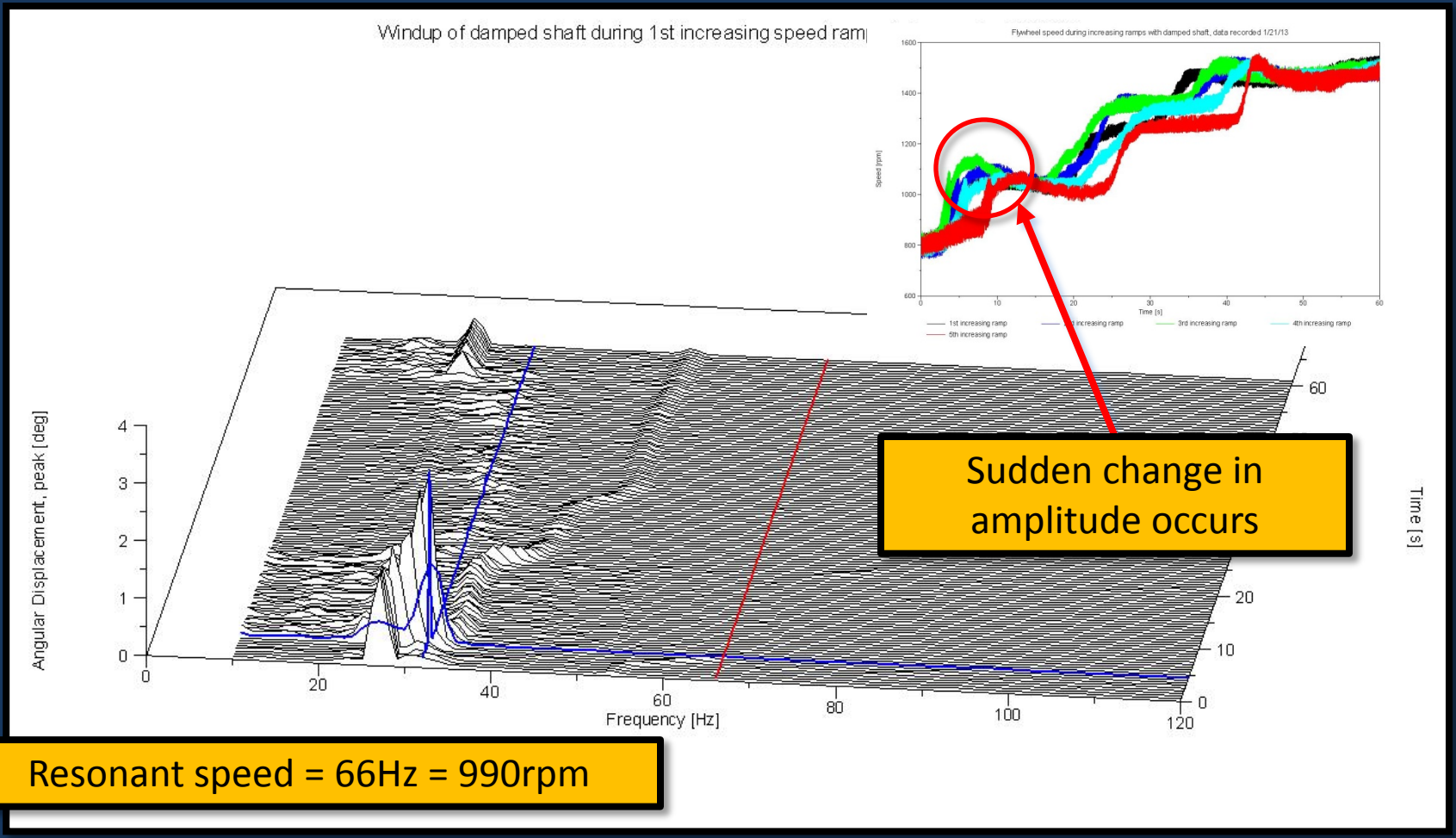
Comparison of ω_n at Different Driveshaft Lengths on Ramp

- 34.5” (Long) Damped Shaft



Comparison of ω_n at Different Driveshaft Lengths on Ramp

- 20.5” (Short) Damped Shaft



Comments About Damped Driveshaft at Different Lengths

- Natural frequency shifted lower in short driveshaft
- Not expected according to stiffness equation
- Still shows driveshaft length has significant effect on vibrational response

Conclusions

- **Driveline of different *stiffness* changed the *torsional vibration dynamics* of the test stand**
  - Both driveshafts behave like hardening springs; solid shaft more so…
  - Shaft wind-up amplitudes larger with damped shaft

Conclusions

- **Driveline of different *length* also change *torsional vibration dynamics* of the test stand**
  - ***Solid Shaft:***
    - Wind-up did not reach isolation at 1500rpm with shorter shaft
    - Natural frequency shifted higher with shorter shaft
  - ***Damped Shaft:***
    - Natural frequency shifted lower with shorter shaft

Next Steps…

- Investigate potential differences between two stands with the same driveshaft
- Measure torsional vibrations at camshaft
- Measure temperature at camshaft-rocker pad contact point
- Correlate torsional vibration with contact temperature

Acknowledgments

- Dr. George Bailey – Engineering and Technical Support
- Fred Gerhart – Technical Support
- Chris Peyton – Technical Support

Questions

Thanks you for your time…

Attachment 8

Motions and Action Items
As Recorded at the Meeting by Bill Buscher

1) Action Item – Surveillance panel chair to solicit suppliers for a GF-5 technology reference oil with ACW performance in the 50 to 90 µm range, preferably closer to 50 µm.

2) Action Item – SP chair to inform Nissan that cylinder head components will not be necessary to include in the upcoming Nissan hardware solicitation to the ASTM labs.

3) Motion – Lab A to issue a detailed report to be included in the meeting minutes of today's meeting, on the regrinding process of Sequence IVA test camshafts, including a timeline and a dataset including camshaft lot numbers and quantities reground, by January 31, 2013. If available differentiate LTMS data within a camshaft lot by reground and non-reground camshafts.

   Dave Glaenzer / Jim Linden / Passed 12 – 0 – 1

4) Motion – Modify the Sequence IVA test procedure to allow the OHT non-nickel plated oil cooler (p/n OHTKA24-006-1), in conjunction with an OHT adapter plate (p/n OHTKA24-005-1), as an acceptable replacement for the Nissan oil cooler. The OHT oil cooler and adapter plate will be introduced at a test lab with an official calibration test, including appropriate notes in the test report comments section, on each stand. Once a lab switches from the Nissan to the OHT oil cooler on a stand, that lab will not switch that stand back to the Nissan oil cooler.

   Bill Buscher / Jerry Brys / Passed 12 – 0 – 1

5) Motion – Modify Sequence IVA test procedure to allow for 48 (from 32) runs per engine assembly and 24 (from 16) runs per cylinder head assembly. Effective 1/24/12.

   Al Lopez / Jerry Brys / Passed 12 – 0 – 1

6) Action Item – Southwest Research Institute to issue procedures for refurbishing Nissan throttle bodies, intake manifolds and exhaust manifolds.

7) Action Item – Lubrizol to issue information on suppler for remanufactured Nissan ECUs.

8) Action Item – Labs to check for supply of damaged Nissan wiring harnesses. If available, return damaged wiring harnesses to OHT for potential refurbishing.

9) Action Item – Keep RO 1006-2 targets constant at N = 25, but review and update targets at N = 30.

10) Motion – Modify section 6.4.1.3 to add a sentence to state “do not modify or alter critical test parts without surveillance panel approval”.

Rich Grundza / Jason Bowden / Passed Unanimously