806427.334 x27 DSP

SRP Application—Sucker Rod Pump Software

SRP Dynacard Troubleshooting

At the time of publication, features of the product described herein are protected by United States Patents numbered 7,168,924 and 7,321,211. Other patents are pending.

The information contained in the manual is considered accurate to the best knowledge of the supplier at the time of publication. The manufacturer assumes no liability for errors that may exist. The supplier reserves the right to change data and specifications without notice.

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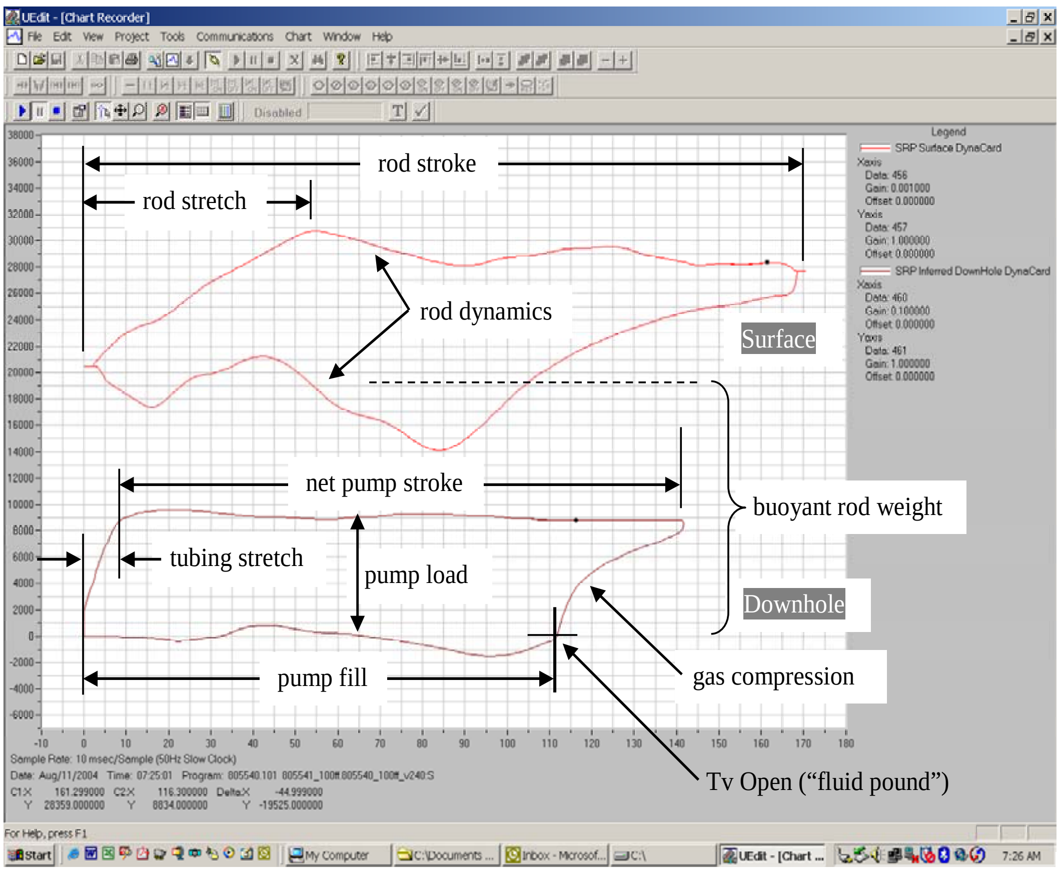
1 Understanding Dynacards

1.1 Overview

The Surface Dynamometer Plot (“Dynacard”) is an X/Y plot of surface (polished) rod load versus surface rod load position. The Inferred Downhole DynaCard is an X/Y plot of downhole pump load versus downhole pump position. Load is on the Y axis; position is on the X axis.

Attention
Prior to analyzing the Dynacards, be sure the pump is functioning and fluid is pumped to the surface. If fluid is not yet to the surface, the Dynacards will be flat or very thin.

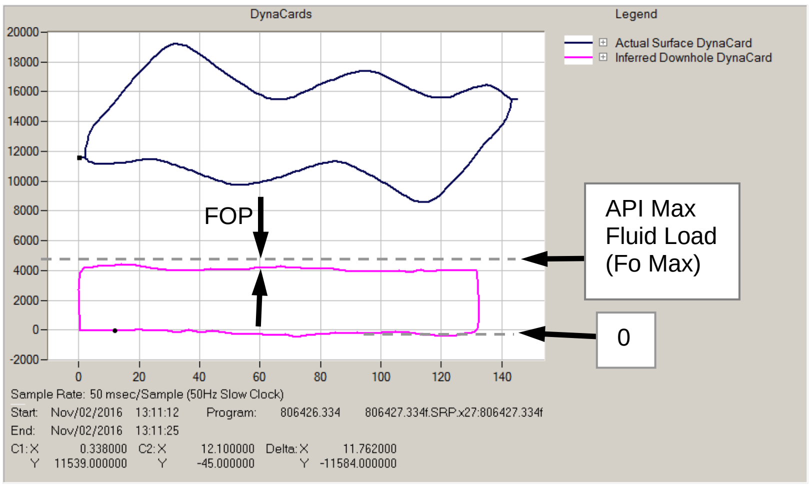
1.2 Example Dynacard



<u>Note:</u> The convention chosen to represent the down-hole (pump) dynamometer graph is “effective” pump load, meaning rod buoyancy force is ignored, thereby causing the down-hole card to rest approximately on zero. The Auto Rod Friction feature further normalizes the pump load to reflect liquid (hydraulic) loading on the pump rather than true load.

1.3 Understanding "API Max Fluid Load" (Fo Max)

The parameter **api max fluid load** on the Rod Pump Menu is extremely useful in verifying and diagnosing the operation of the pump. The **api max fluid load** is the maximum theoretical pump load when the well is pumped-off, also known as Fo Max. The **api max fluid load** is a reference line on the downhole pump Dynacard, as shown below:



The average liquid pump load on the downhole DynaCard should not exceed the **api max fluid load**. If so, the **plunger diameter, pump intake depth**, or **rod friction parameter**(s) may be wrong.

When the well is pumped off (fluid level is at the pump intake), the average upstroke downhole liquid pump load should equal the **api max fluid load**.

If there is fluid over the pump (the well is not pumped off), the upstroke downhole liquid pump load should be less than the **api max fluid load**, as shown in the illustration above.

Note: The convention chosen to represent the down-hole (pump) dynamometer graph is "effective" pump load, meaning rod buoyancy force is ignored, thereby causing the down-hole card to rest approximately on zero. The Auto Rod Friction feature further normalizes the pump load to reflect liquid (hydraulic) loading on the pump rather than true load.

2 Troubleshooting Actual Dynacards

2.1 Overview

The following reference dynacards are used to troubleshoot the appearance of the Actual dynacards and to assist the user in identifying pumping equipment problems. This applies to load-cell and no load-cell derived dynacards.

The “baseline” dynacards represents the theoretically correct cards for the example well; they are labeled as "Correct" or "Reference." **These dynacards represent an example well; the appearance of dynacards will vary from well to well, depending upon the rod makeup, pump, and well characteristics.**

The subsequent dynacards (labeled as "Incorrect") illustrate a distortion of the shape or position of the correct dynacards, followed by a description of the problem. If the actual dynacards exhibit the characteristic shape of the "Incorrect" cards, take the specified action.

The convention chosen to represent the down-hole (pump) dynamometer graph is to use pump “effective” load, meaning rod buoyancy force is ignored, thereby causing the down-hole card to rest approximately on zero. The Auto Rod Friction feature further normalizes the pump load to reflect liquid (hydraulic) loading on the pump rather than true load.

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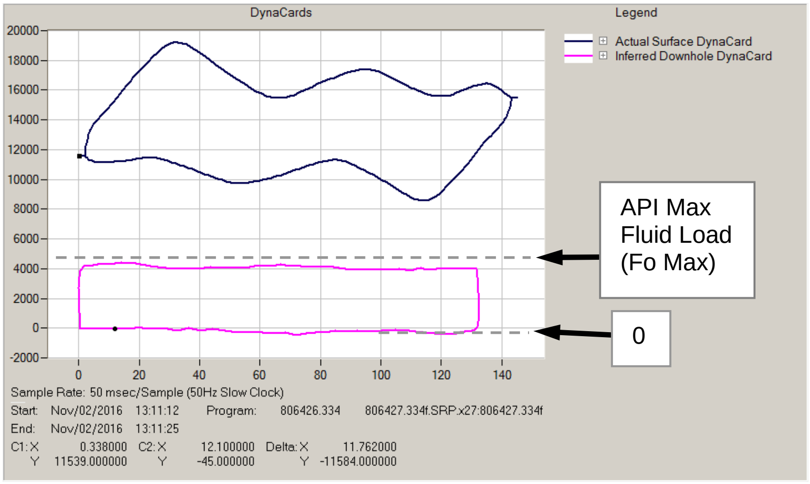
2.2 Plot Dynacards

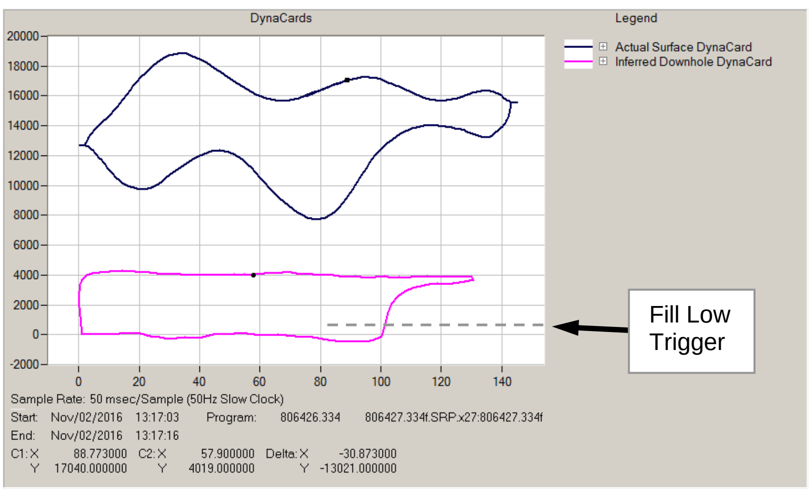
- ❑ Using the Chart Recorder, plot Surface Dynacard and Inferred Downhole Dynacard on the same chart.
- ❑ Check the shape, thickness, and vertical location of both dynacards. Adjust parameter values as necessary to correct. Use the following sections for assistance.
- ❑ Note: If **auto rod friction enable** parameter is enabled, the controller will automatically adjust the rod friction compensation, thereby ensuring that actual downhole cards are neither too fat nor too thin for the given downhole data. If **auto rod frict pan** parameter is enabled, the controller will automatically adjust the rod friction to correct for Downhole Dynacard “panhandle” and fluid compression curve. While troubleshooting the downhole pump, it may be beneficial to disable the **auto rod friction enable**. Note that if **flow frctn gain** is non-zero, the downhole card will correctly maintain the dynacard card thickness accordingly (the downhole card will be fatter).

2.3 Baseline Actual Dynacards – 100% Pump Fill



This baseline chart illustrates the theoretically correct shape and position of the dynacards for the example well with 100% pump fill and modest fluid over pump (FOP). **Actual appearance will vary from well to well!**

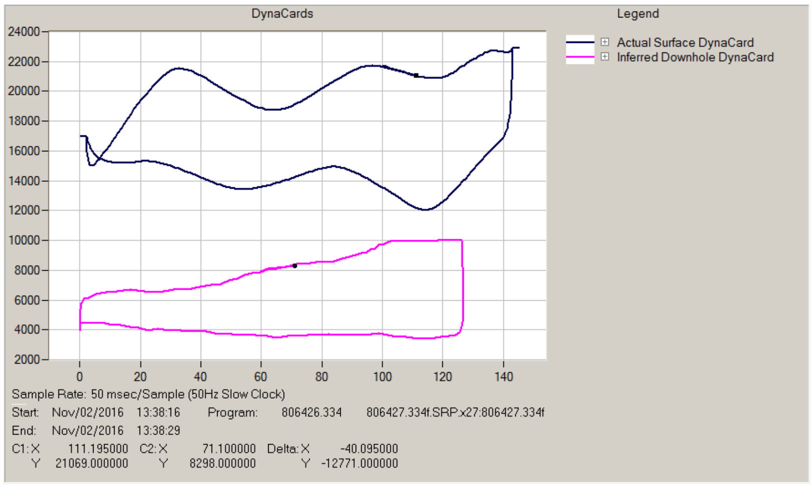
2.4 Baseline Actual Dynacards – 75% Pump Fill



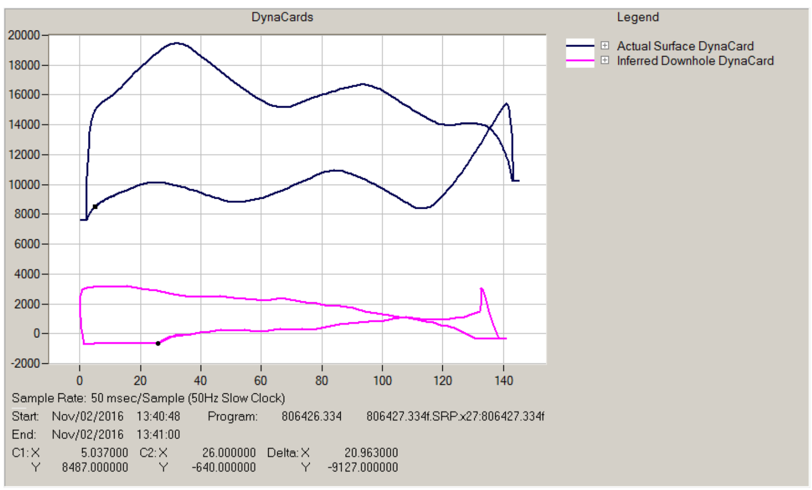
This baseline chart illustrates the theoretically correct shape and position of the dynacards for the example well with 75% pump fill. **Actual appearance will vary from well to well!**

Note: The convention chosen to represent the down-hole (pump) dynamometer graph is "effective" pump load, meaning rod buoyancy force is ignored, thereby causing the down-hole card to rest approximately on zero. The Auto Rod Friction feature further normalizes the pump load to reflect liquid (hydraulic) loading on the pump rather than true load.

2.5 Distorted Actual Dynacards – Well ID Required



Incorrect



Incorrect

100% pump fill example.

Symptom:

Dynacards are distorted when not using a load cell. Distortion is typically prominent at the ends, characteristically too thick or too thin at the ends, including flaring or crossing over / slanting. Actual distortion may vary from the two examples shown above.

Problem:

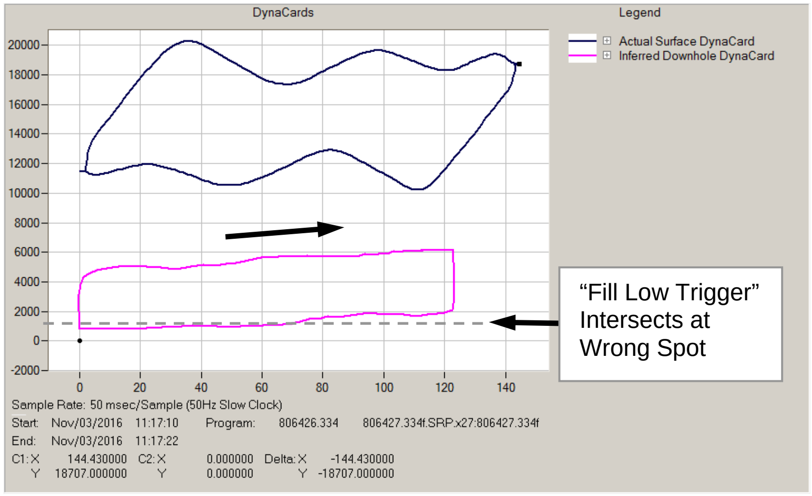
Error in pumping unit identification: counterweight value, phase angle, rotary inertia, articulating weight, gearbox efficiency, reference (inclinometer) polarity, or rotation direction.

Solution:

Check Calibrate Inclinometer chart for proper Pumping Unit dimensions. Verify proper **rotation direction** parameter (CW or CCW with wellhead to right). Verify that pumping unit up and down motion matches the **pump direction** on the Gear/Crank Menu (**reference polarity**). Verify downhole rod data. Run **Well ID**. If necessary, try different **gearbox efficiency** value and re-run **Well ID**. If necessary, as a last option, increase dynacard **deadzone** to filter end disturbances.

<u>**Note**</u>: Actual distortion will vary from the examples shown above!

2.6 Tilted Actual Dynacards



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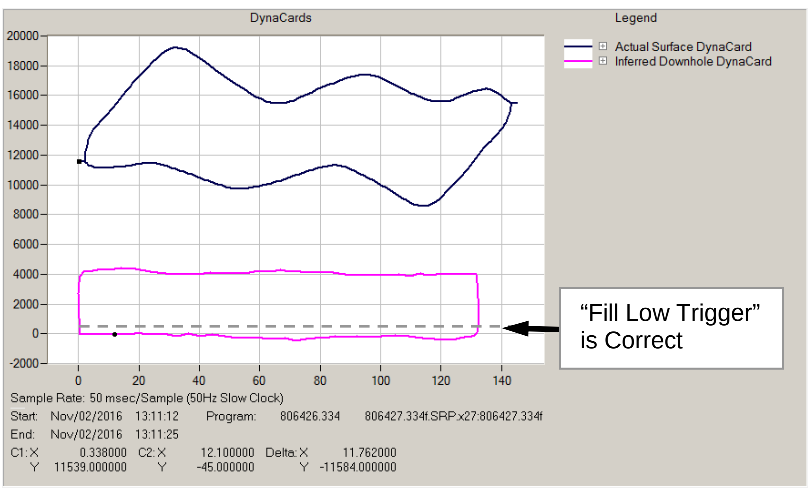


Correct

100% pump fill example.

Symptom:

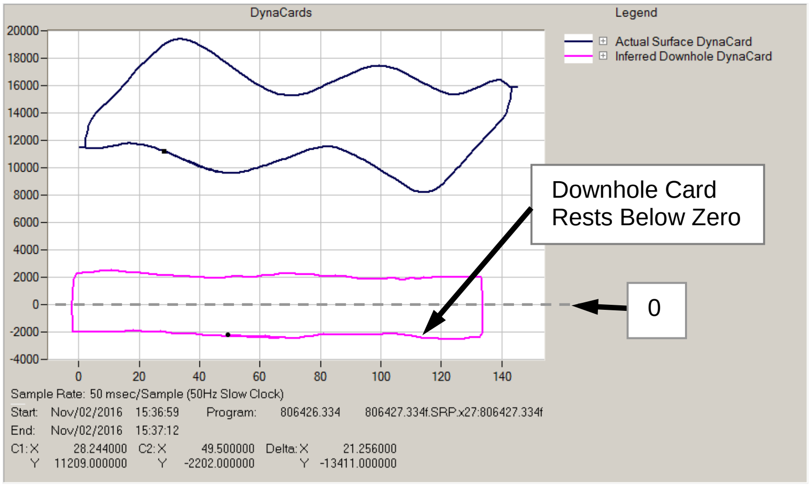
Actual dynacards are tilted up (or down), causing **pump fill monitor** to be wrong. 100% pump fill is incorrectly measured less than 100%. Above example is 100% pump fill incorrectly measured as 60%.

Solution:

If tilt changes with pumping speed (SPM), then **articulating weight** is wrong – adjust value until problem is solved. Otherwise adjust the **dynacard tilt offset** or **downhole tilt offset** parameter (positive or negative) to level the card and correct the pump fill reading.

Note: This condition may be caused by a tight or uneven pump barrel. Using the **downhole tilt offset** parameter will normalize the downhole dynacard card to reflect liquid pump load rather than “true” pump load.

2.7 Actual Downhole Dynacard Rests Below Zero



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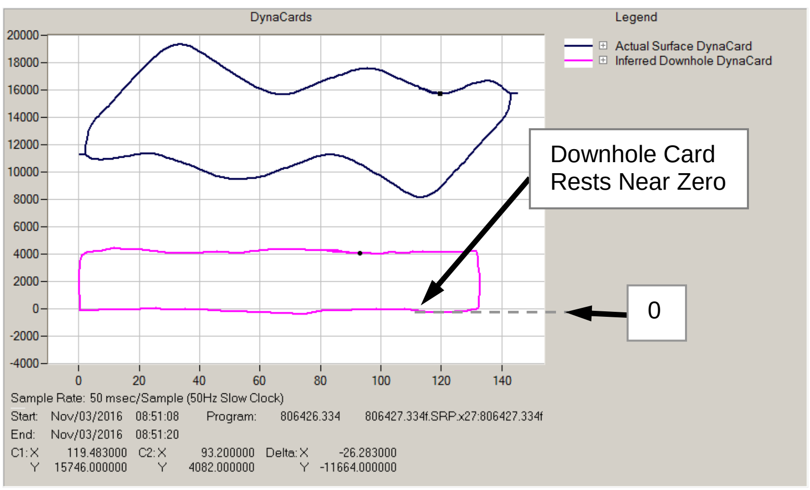


Correct

100% pump fill example.

Symptom:

Downhole dynacard rests below zero.

Problem:

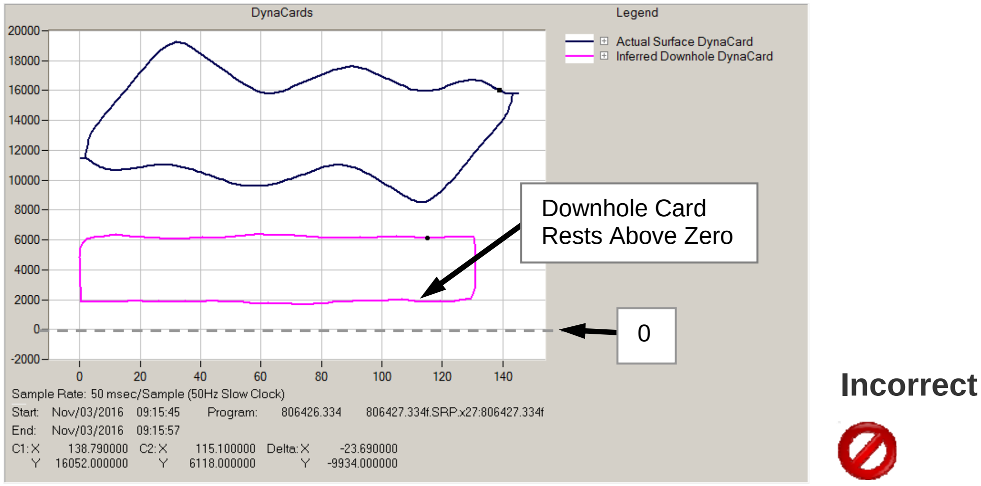
Rod weight parameter is too large because **rod length**, **rod diameter**, or other rod makeup parameters are incorrect; rod friction and/or **oil gravity** parameter values may also be in error.

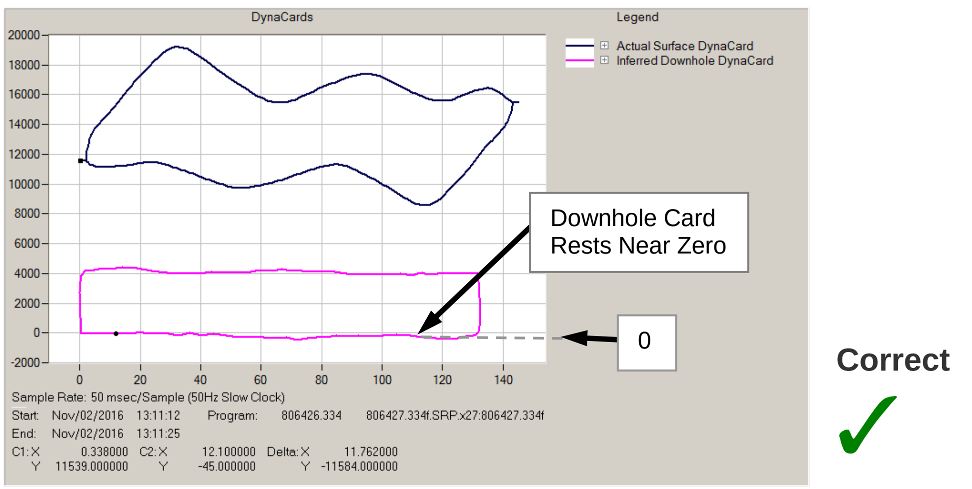
Solution:

Verify rod makeup on Rod/Pump menu. Verify that pump depth, rod section lengths, and rod section diameters are all correct. If necessary, the **rod weight offset** parameter can be used to offset the rod weight. Rod friction and stuffing box friction will also affect dynacard position – see the following sections. Verify **oil gravity**.

Note: The convention chosen to represent the down-hole (pump) dynamometer graph is pump "effective" load, meaning rod buoyancy force is ignored, thereby causing the down-hole card to rest approximately on zero. The Auto Rod Friction feature further normalizes the pump load to reflect liquid (hydraulic) loading on the pump rather than true load.

2.8 Actual Downhole Dynacard Rests Above Zero





100% pump fill example.

Symptom:

Downhole dynacard rests above zero.

Problem:

Rod weight parameter is too small (incorrect rod makeup settings), or hole in tubing is causing increased buoyant rod weight, or rod friction or **oil gravity** parameter is incorrect.

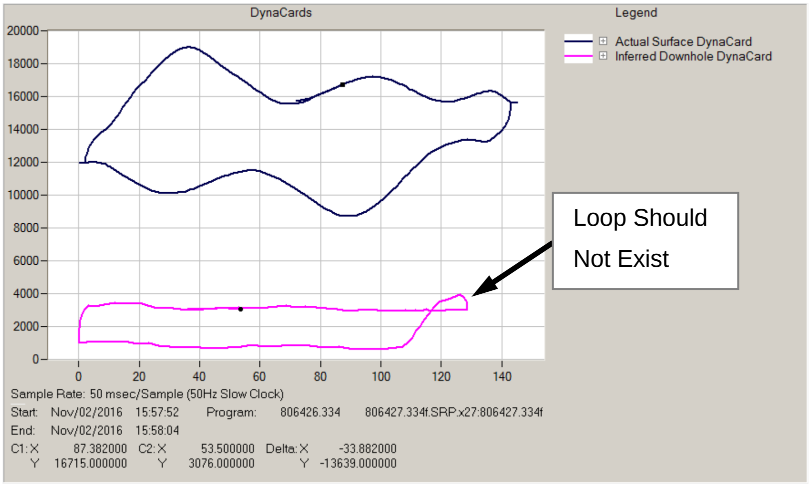
Solution:

Correct rod makeup on Rod/Pump menu. Verify that pump depth, rod section lengths, and rod section diameters are all correct. If necessary, the **rod weight offset** parameter can be used to offset the rod weight. Rod friction and stuffing box friction will also affect dynacard position – see the following sections. Verify **oil gravity**.

If this problem has developed over time, and the upstroke pump load is below the **api max fluid load**, then this condition may indicate a hole in the tubing. Verify that fluid is being produced at the surface.

Note: The convention chosen to represent the down-hole (pump) dynamometer graph is pump "effective" load, meaning rod buoyancy force is ignored, thereby causing the down-hole card to rest approximately on zero.

2.9 Downhole Dynacard Too Thin – Rod Friction



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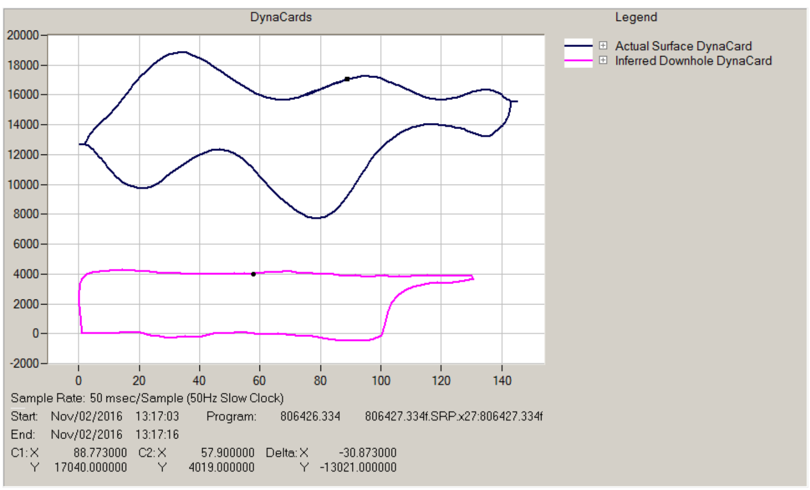


Correct ✓

75% pump fill example.

Symptom:

Downhole dynacard is too thin for the given FOP, looping around during incomplete pump fill and possibly resting above zero.

Problem:

Actual rod friction is less than the **rod friction** parameter.

Solution:

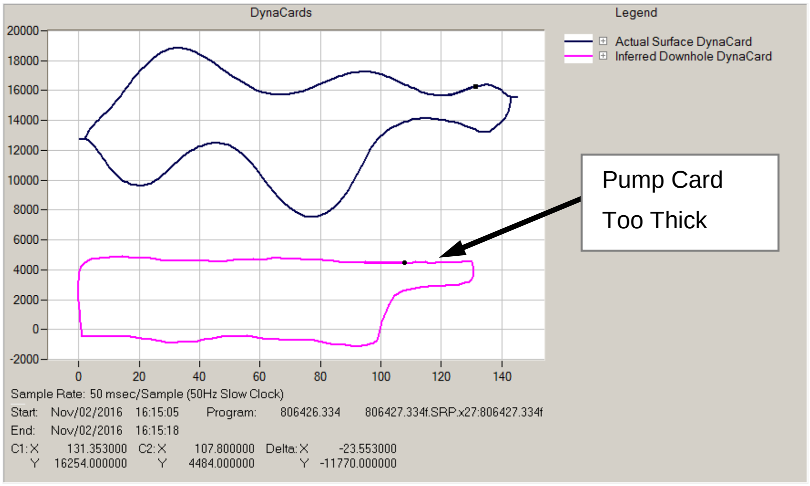
Enable **auto rod friction enable**. Decrease **rod friction** parameter.

When **auto rod friction enable** parameter on the Dynacard Menu is set to ENABLED, the rod friction will be internally limited to ensure that the downhole dynamometer plot is neither too thick nor too thin as compared to the theoretical limit. If the downhole dynacard appears too thin during auto rod friction mode, verify the **plunger diameter** and **pump depth** parameters.

When **auto rod friction enable** is ENABLED, the **rod friction** parameter becomes the rod friction floor – minimum rod friction.

Note: The Auto Rod Friction feature will normalize the downhole dynacard to reflect liquid pump load rather than "true" pump load.

2.10 Downhole Dynacard Too Thick – Rod Friction



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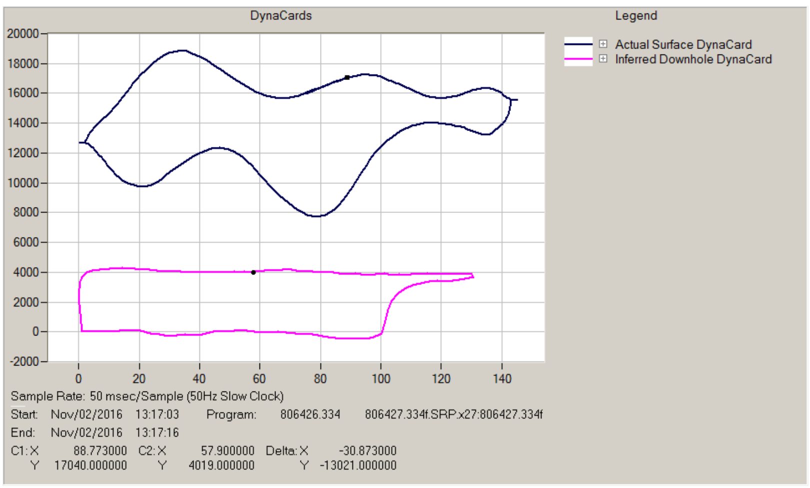


Correct

75% pump fill example.

Symptom:

Downhole dynacard is too thick for the given FOP and/or expected pump friction, or “pan handle” is too thick during incomplete pump fill. In general, the tip of the “pan handle” should be thin given reasonable pump friction.

Problem:

Actual rod friction is more than the **rod friction** parameter.

Solution:

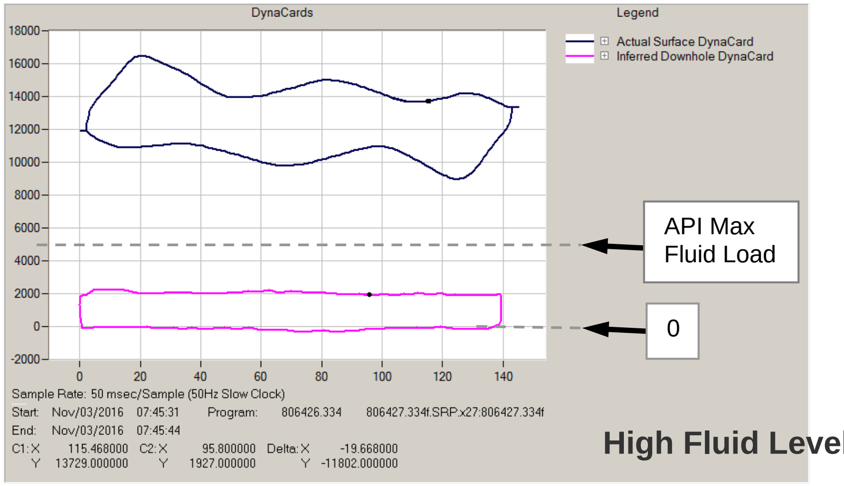
Enable **auto rod friction enable**. Enable **auto rod frict pan**. Increase **rod friction** parameter.

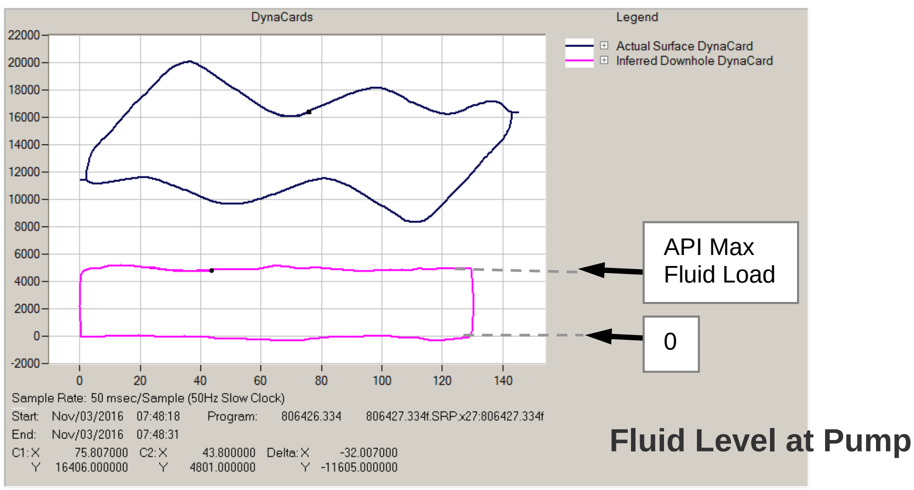
When **auto rod friction enable** parameter on the Dynacard Menu is set to ENABLED, the rod friction will be internally limited to ensure that the downhole dynamometer plot is neither too thick nor too thin as compared to the theoretical limit. If the downhole dynacard appears too thin during auto rod friction mode, verify the **plunger diameter** and **pump depth** parameters.

When **auto rod frict pan** is ENABLED, the **auto rod friction** parameter will be corrected accordingly, to ensure the tip of the panhandle is thin (providing nominal pump friction).

<u>**Note:**</u> The Auto Rod Friction feature normalizes the downhole dynacard card to reflect liquid pump load rather than “true” pump load.

2.11 High Casing Fluid Level (High FOP)





100% pump fill example.

Symptom:

Actual Surface and Downhole dynacards are thin, and the downhole card rests near zero. The **pump fill monitor** value may be -2.

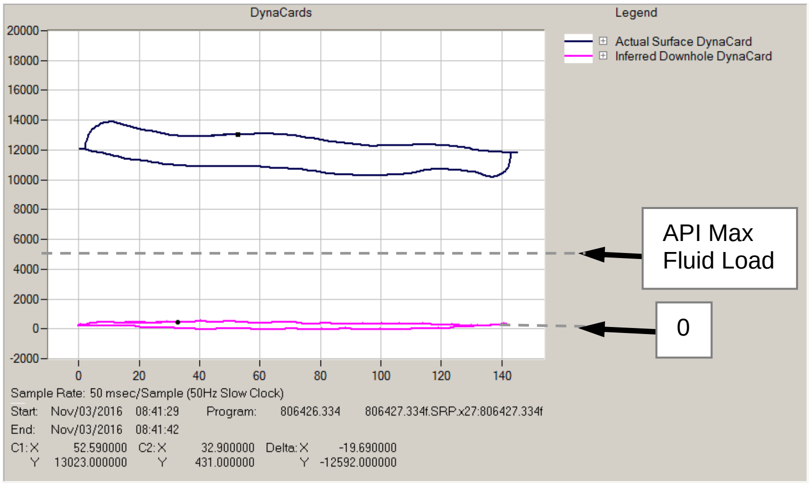
Problem:

This condition can be caused by high casing fluid level. This could also simply indicate a new startup – no fluid to the surface yet. High fluid level is not necessarily a problem, if it is expected or even desired.

Solution:

High fluid level is indicated. If measured pump flow rate is less than expected, this condition may be caused by excessive pump slippage or slow pumping rate. Wait for fluid to reach the surface and for the casing fluid to pump down. Check for fluid flow at surface. Check for free-flowing well. If a stuck travelling valve is suspected, try Pump Clean mode.

2.12 Free Flowing Well / Stuck Traveling Valve / Deep Rod Part



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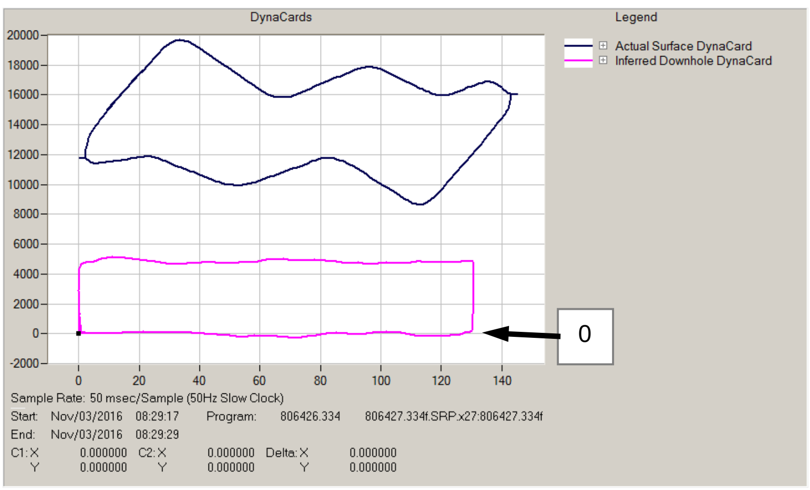


Correct

Symptom:

Actual Surface and Downhole dynacards are extremely thin, and the downhole card rests near zero pounds. The **pump fill monitor** value is usually -2.

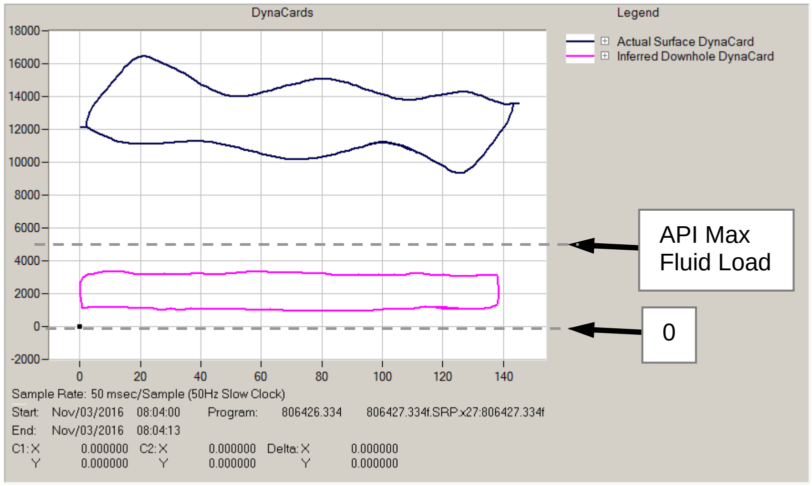
Problem:

This condition can be caused by very high casing fluid level, free-flowing well, a stuck or broken traveling valve, deep rod part, or an unseated pump. This could also simply indicate a new startup – no fluid to the surface yet (and casing fluid level not yet pumped down).

Solution:

If it is a new startup, wait for fluid to reach the surface. Check for fluid flow at surface. Check for free-flowing well. Re-seat pump. If a stuck travelling valve is suspected, try Pump Clean mode.

2.13 Fluid Not to Surface / Tubing Leak



Symptom:

Actual Surface and Downhole dynacards are thin and the downhole card rests above zero. Maximum pump load is less than **api max fluid load**. The **pump fill monitor** value is sometimes -2.

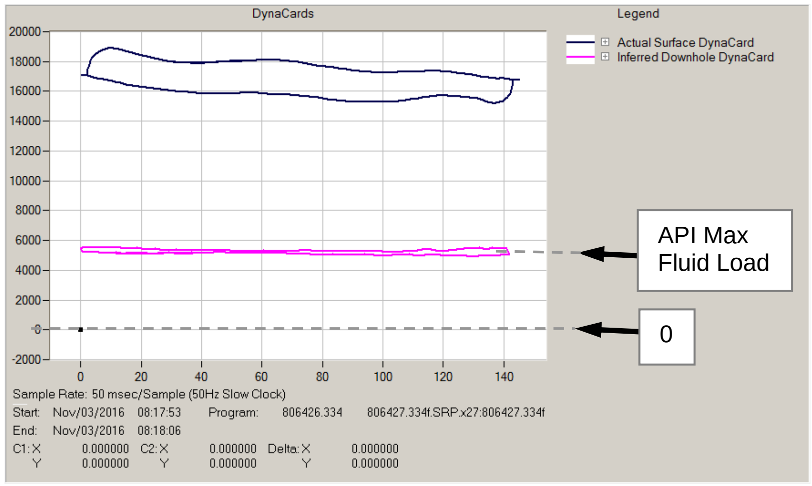
Problem:

This condition can be caused by no fluid to the surface (tubing not full), or a leaky tubing (the height of the leak being a function of the load). This could also simply indicate a new startup – no fluid to the surface yet. This could also indicate the presence of gas in the tubing (decreasing the fluid density gradient). The hallmark of this condition is an uncharacteristically high downstroke load associated with a loss of buoyancy on the rod. If it is a new startup, this may simply indicate that the dynacards may need to be calibrated or some parameter values are wrong.

Solution:

If it is a new startup, wait for fluid to reach the surface. Check for fluid flow at surface. Check for tubing leak. Dynacards may simply need to be calibrated.

2.14 Stuck Standing Valve



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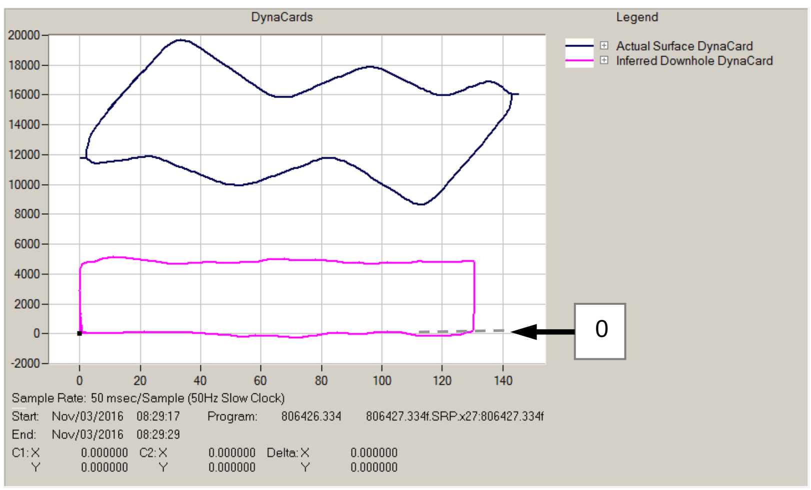


Correct ✓

Symptom:

Actual Surface and Downhole dynacards are extremely thin, and the downhole card rests near the **API max fluid load** (the Fo max theoretical fluid load). The **pump fill monitor** value is usually -2.

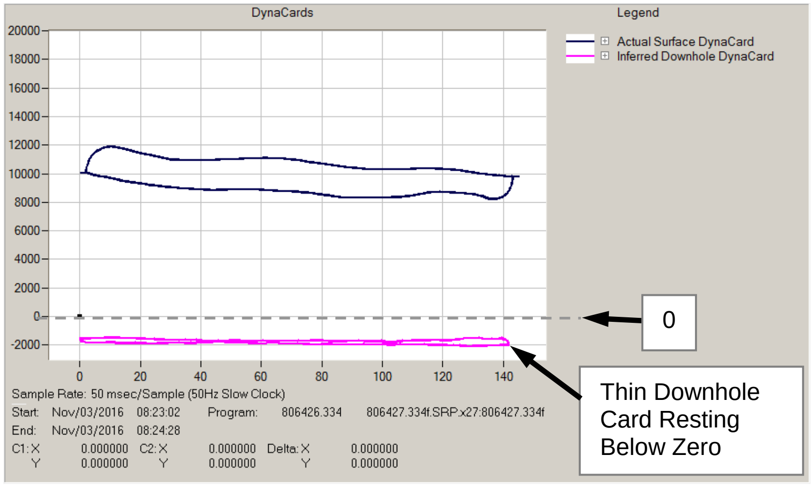
Problem:

This condition is usually caused by a stuck or broken pump standing valve. (The pump is lifting and lowering the entire weight of the rod plus fluid.)

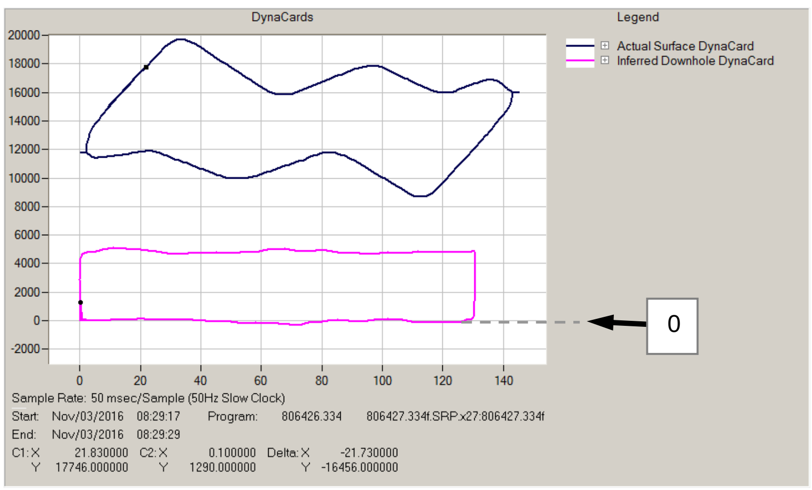
Solution:

Repair pump. Try Pump Clean mode.

2.15 Parted Rod



Incorrect



Correct

100% pump fill example.

Symptom:

Actual Surface and Downhole dynacards are extremely thin and too low (the downhole card rests below zero). The **pump fill monitor** value is usually -2.

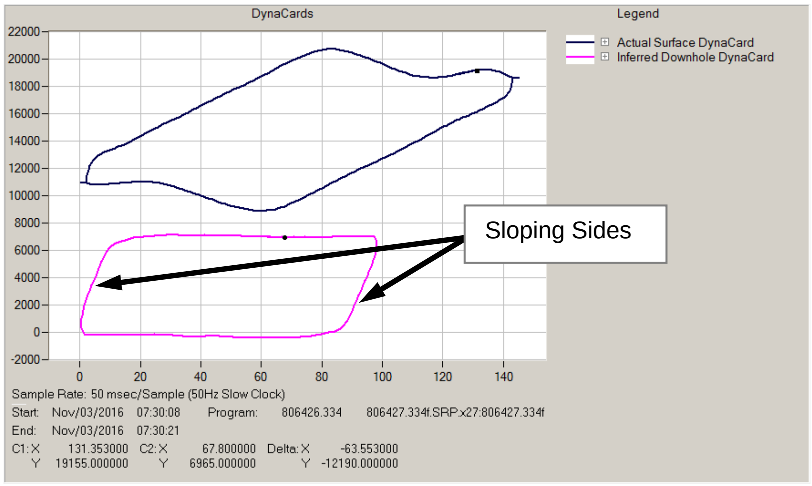
Problem:

This condition is usually caused by a parted rod. The depth of the part can be determined by the pump load. The lower the load, the higher the rod part. If the surface card rests on zero, the rod part is near the surface. If the downhole card rests on zero, the rod part is deep, near the pump.

Solution:

Repair rod.

2.16 Actual Downhole Dynacard Has Sloping Sides



100% pump fill example.

Symptom:

Downhole dynacard sides are sloped.

Problem:

This condition can be caused by either an unanchored or loose tubing anchor, or by rod stiffness less than predicted.

Solution:

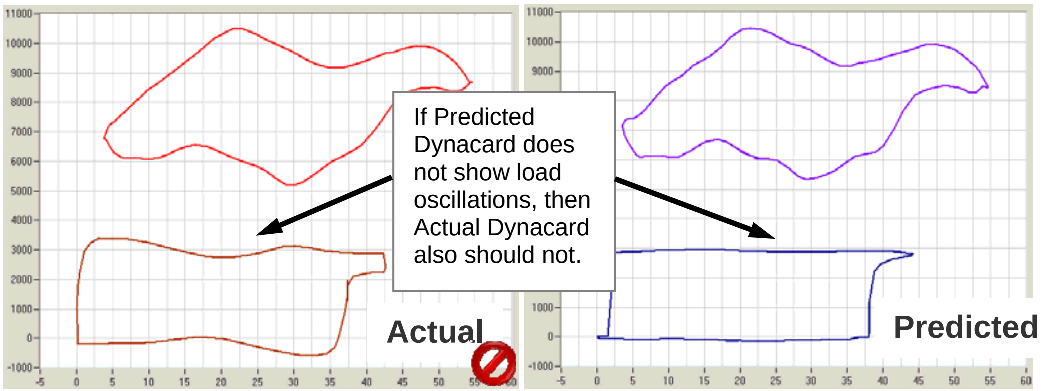
Verify that rod makeup parameters are entered correctly. If rod makeup parameters are wrong, then the predicted rod stiffness will be wrong, thus causing this effect. If the rod parameters are believed to be correct, then this condition likely indicates either an unanchored or loose tubing anchor.

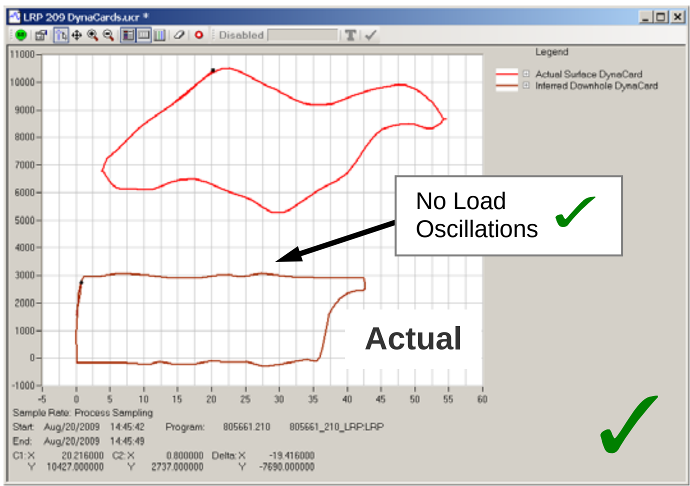
If tubing is anchored and the anchor is believed to be intact, decreasing the **rod stiffness gain** parameter to straighten the dynacard sides.

Note:

If downhole dynacard sides are sloping in the opposite direction as shown (backwards), then first verify rod makeup parameters. If rod makeup parameters are correct, increase the **rod stiffness gain** parameter to straighten the dynacard sides.

2.17 Erroneous Oscillations in Downhole Dynacard





Symptom:

Actual downhole dynacard has significant load oscillation which are not present in Predicted downhole dynacard. Oscillations in actual downhole card should only exist if they also exist in the predicted downhole dynacard. <u>Oscillations observed in Predicted downhole dynacard are caused by fluid dynamics; such oscillations are normal and should also be observed in actual downhole dynacard – do not try to eliminate fluid dynamics!</u>

Problem:

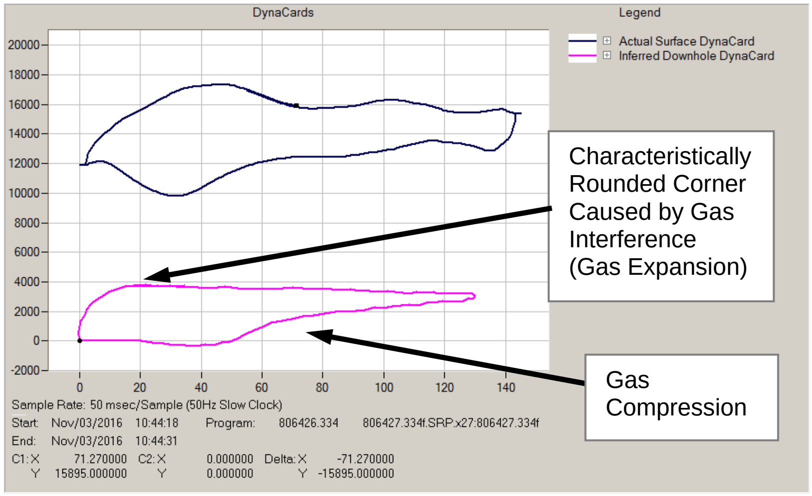
This condition can be caused by high rod/pump friction causing stick/slip behavior, or by an improper rod mass calculation, possibly caused by incorrect rod makeup data. While downhole dynamometer "true" load should reflect pump stick/slip behavior, it may cause errors in **pump fill monitor**, and hence the desire to normalize the downhole dynacard to reflect liquid loading.

Solution:

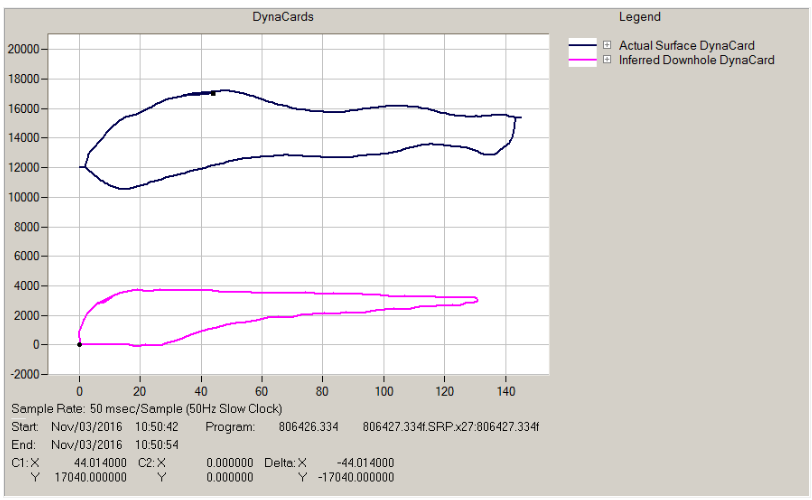
Set **dynamic downhole filter** to ENABLE. Also verify that rod makeup parameters are entered correctly. If rod makeup parameters are incorrect, the rod mass will be wrong, thus causing this effect. If the rod parameters are believed to be correct, then adjust the **rod mass gain** on the Dynacard Menu until the oscillations are minimized. For example, it may be necessary to set the gain to 1.1. The default value for **rod mass gain** is 1.

<u>Note:</u> Oscillations in the Predicted downhole dynacard are caused by fluid dynamics. Such oscillations are normal and should also be observed in actual downhole dynacard!

2.18 Gas Interference & Gas Lock



30% Liquid Pump Fill (40% Pump Fill Monitor)



0% Liquid Pump Fill (Gas-Locked)

Gas interference is the presence of excessive gas in the pump, limiting the liquid production rate. It is characterized by gas compression on the down-stroke and gas expansion on the upstroke. Gas locking is an extreme case where the valves never open, producing neither gas nor liquid. Gas locking is caused by the presence of pump gas coupled with the pump clearance volume at the bottom of the down-stroke.

Symptom:

Rounded upstroke load buildup in the dynacard. Lost production.

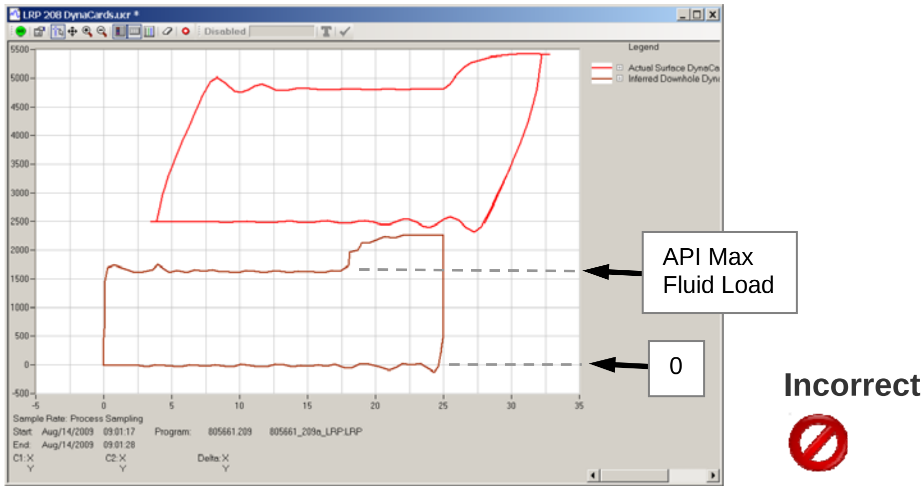
Problem:

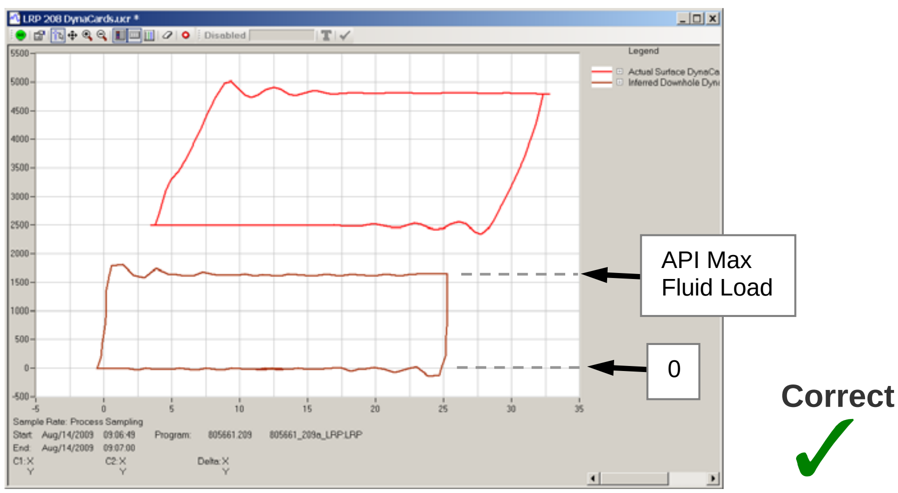
Too much pump spacing between the traveling and standing valves. Possibly no liquid well inflow.

Solution:

Re-space the pump lower to increase pump compression ratio. Improve gas separation. Increase plunger clearance to increase slippage.

2.19 Sticking Pump





100% pump fill example.

Symptom:

Actual Surface and Downhole dynacards show unusual increased load somewhere within the upstroke. Downhole dynacard rests correctly near zero pounds. Load during start of downstroke may also be briefly too high if pump does not release.

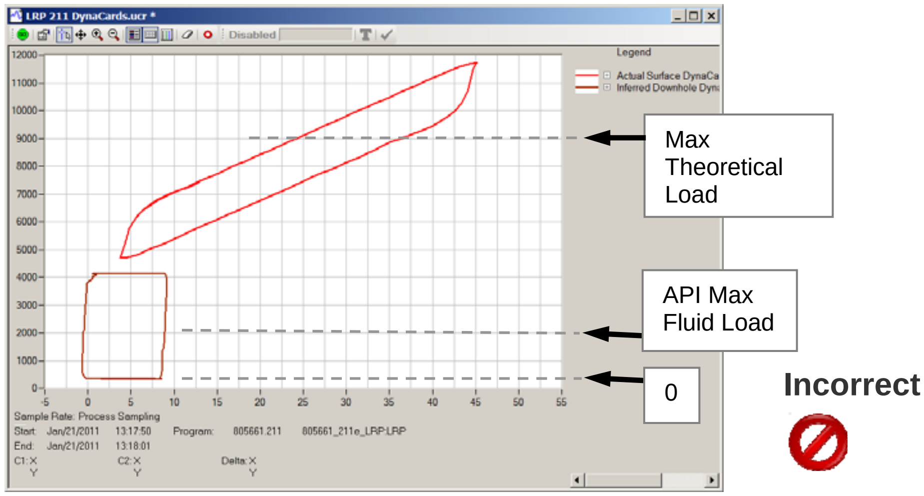
Problem:

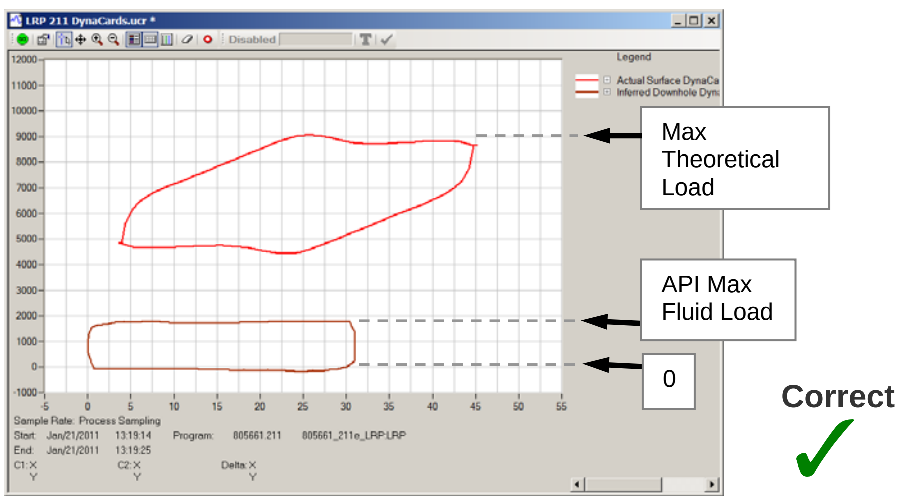
This usually indicates a stuck or sticking pump, possibly caused by scale or paraffin buildup.

Solution:

Repair pump.

2.20 Stuck Pump / Frozen or Closed Flow Line





100% pump fill example.

Symptom:

Actual Surface dynacard shows continually increasing load as position increases. Maximum load on Surface and Downhole dynacard is greater than the API Max Fluid Load.

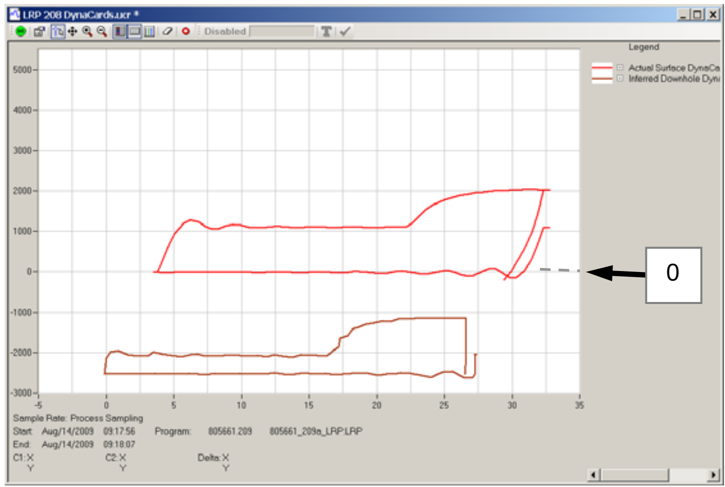
Problem:

This usually indicates a stuck pump or frozen/closed flow line.

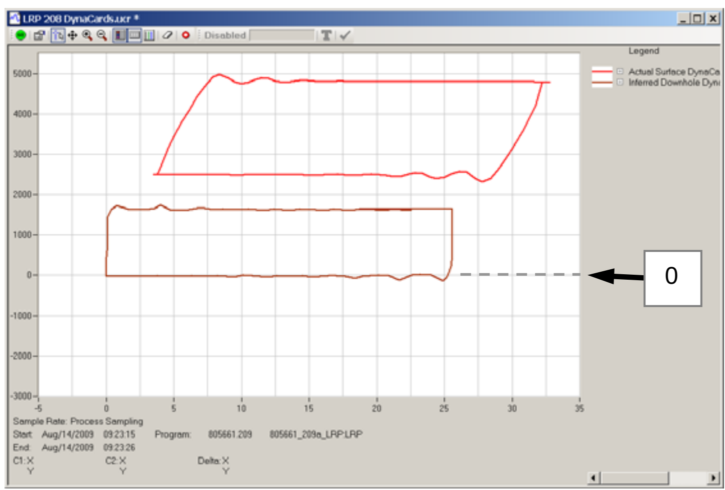
Solution:

Repair pump or flow line.

2.21 Erratic Dynacards -- Sticking or Floating Rod



Incorrect



Correct

100% pump fill example.

Symptom:

Erratic dynacards. Actual Surface dynacard has very low (or zero) load somewhere within the downstroke (downhole card rests below zero). If the rod remains stuck into the next upstroke, the upstroke load will suddenly increase as the pumping unit re-couples to the rod (as shown above).

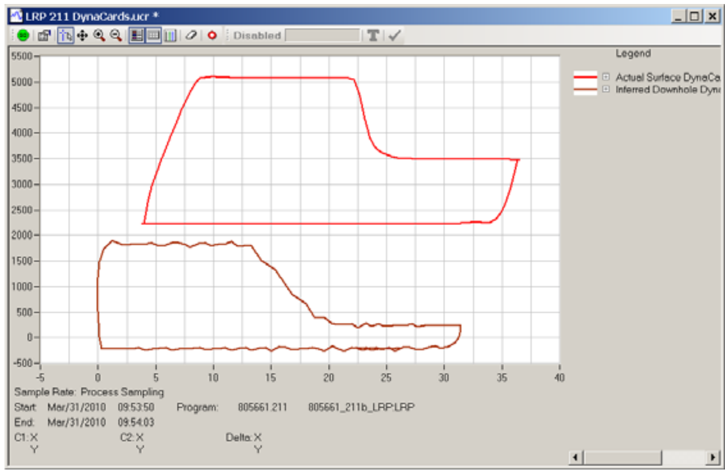
Problem:

This usually indicates a sticking or floating rod, possibly caused by scale or paraffin buildup.

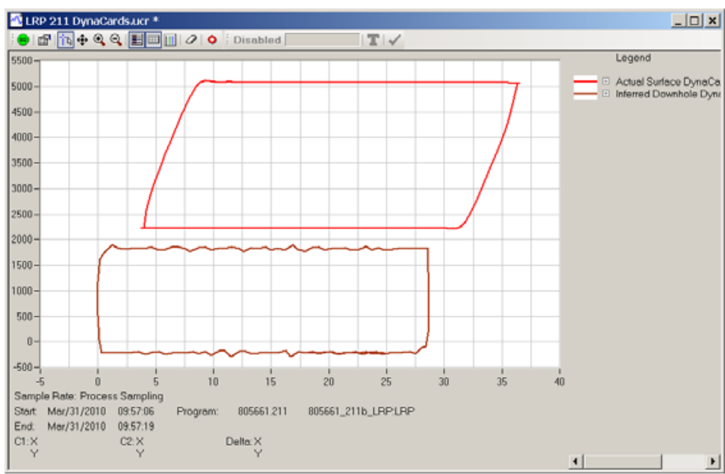
Solution:

Repair rod stick.

2.22 Damaged Pump Barrel



Incorrect



Correct

100% pump fill example.

Symptom:

Actual Surface and Downhole dynacards show unexpected drop in load during upstroke.

Problem:

This usually indicates a damaged pump barrel.

Solution:

Repair pump.

3 Verifying Predicted Dynacards

3.1 Overview

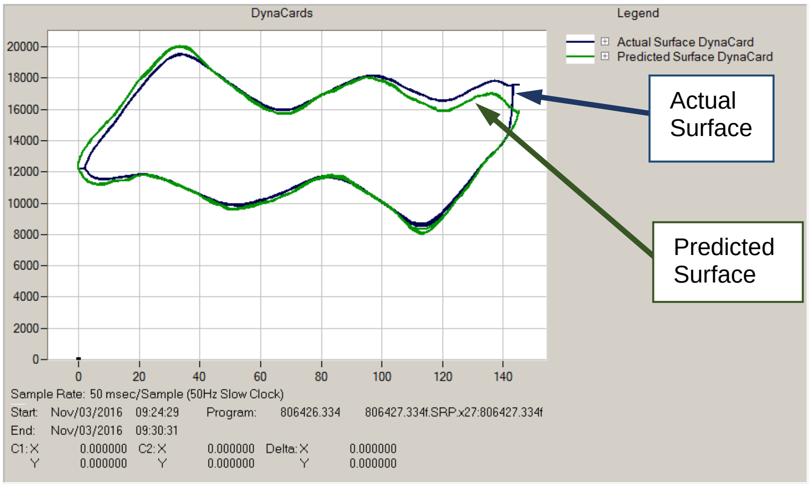
This section illustrates how certain parameter values affect the appearance of the predicted surface and predicted downhole dynacards. Setup personnel should strive to match predicted surface dynacard to actual surface dynacard (make them look the same). Matching predicted surface dynacard to actual surface dynacard results in the most accurate inferred (actual) downhole dynacard by assuring a well-tuned rod model. Differences between predicted and actual dynacards indicate incorrect setup parameter(s) or pumping problems such as a sticking pump, parted rod, broken pump, etc.

Note: If **fill simulation mode** parameter on the Simulate Menu is set to AUTO, the predicted fluid level and pump fill characteristics will automatically track the actual measured **fluid level monitor** and **liquid fill monitor**. If it is desired to manually set the predicted fluid level and pump fill characteristics, set **fill simulation mode** parameter on the Simulate Menu to KEYPAD. The desired fluid level can then be entered in the **sim fluid over pump** parameter, and the desired pump fill can be entered into the **sim liquid fill** parameter (both located on the Simulate Menu).

3.2 Plot Dynacards

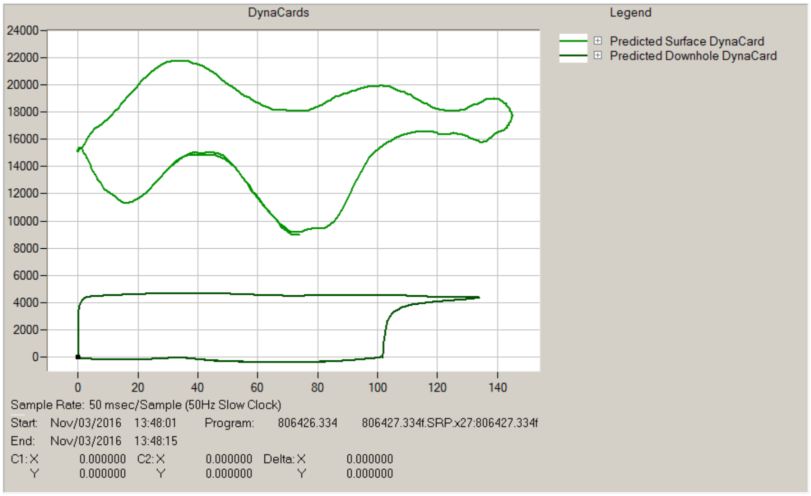
- ❑ Using the Chart Recorder, plot Actual Surface Dynacard and Predicted Surface Dynacard on the same chart.
- ❑ Compare the two signals. Differences likely suggest an error in the predicted model. For example: wrong plunger diameter, incorrect rod friction, too little rod damping, too much rod damping, incorrect rod stiffness, etc. If so, adjust parameter values as necessary to match the predicted dynacard to the actual surface dynacard. Use the following sections for assistance in how to adjust the Predicted modeling.
- ❑ To ensure good Predicted Dynacard match, verify that **tubing prs** and **casing prs** (pressure) values are properly entered. For best results, install tubing and casing pressure sensors.

3.3 Example of Matching Predicted & Actual Surface Dynacards



- ❑ When Actual and Predicted surface dynacards closely match, the rod model is well tuned. With a well tuned rod model, the user can be confident that the inferred actual downhole card is also accurate.
- ❑ Use the following guildlines to assit in matching the predicted surface dynacard to the actual surface dynacard.

3.4 Baseline Predicted Dynacards



75% pump fill example.

The “baseline” Predicted Dynacards represents theoretically correct dynacards for the example well and pumping unit characteristics.

The Predicted Dynacards shape and position should roughly match the Actual Dynacards. Some differences are to be expected, since actual wells conditions may not match theoretical conditions.

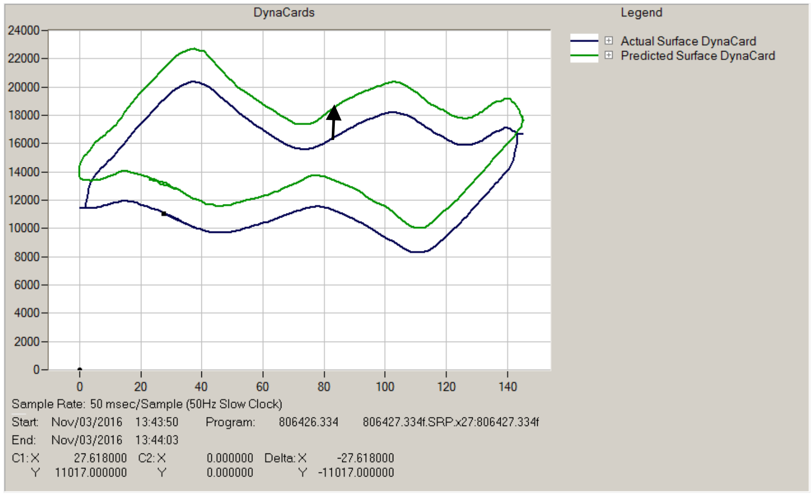
If the Predicted and Actual Dynacards significantly vary from each other, then either the Pumping unit or Rod/Pump setup parameters are wrong, or the pumping system is experiencing a problem.

If necessary, adjust parameters to achieve the desired results -- match predicted and actual dynacards.

The following examples will give some guidance.

The following dynacards represent an example well. The appearance of dynacards will vary from well to well, depending upon the rod makeup, pump, and well characteristics!

3.5 Predicted Surface Dynacard is Higher than Actual – Rod Weight is Wrong



Incorrect

100% pump fill example.

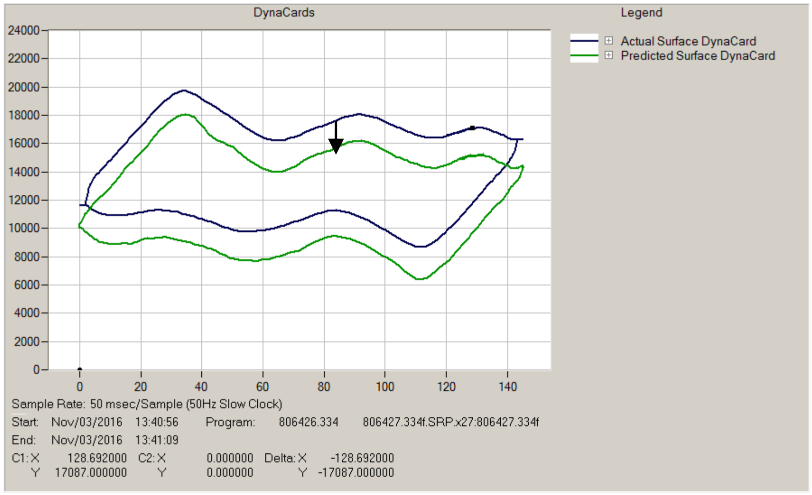
If the Predicted Surface Dynacard is higher than the Actual Surface Dynacard, then the modeled Rod Weight is too large.

Check setup parameters for rod lengths, diameters, and coupler type.

If necessary, the **rod weight offset** parameter can be adjusted to manually offset the Predicted rod weight (positive or negative). The **dynacard load offset** parameter can be used to manually offset the Actual rod weight (positive or negative).

Rod friction and stuffing box friction will also affect DynaCard position.

3.6 Predicted Surface DynaCard is Lower than Actual – Rod Weight is Wrong



Incorrect

100% pump fill example.

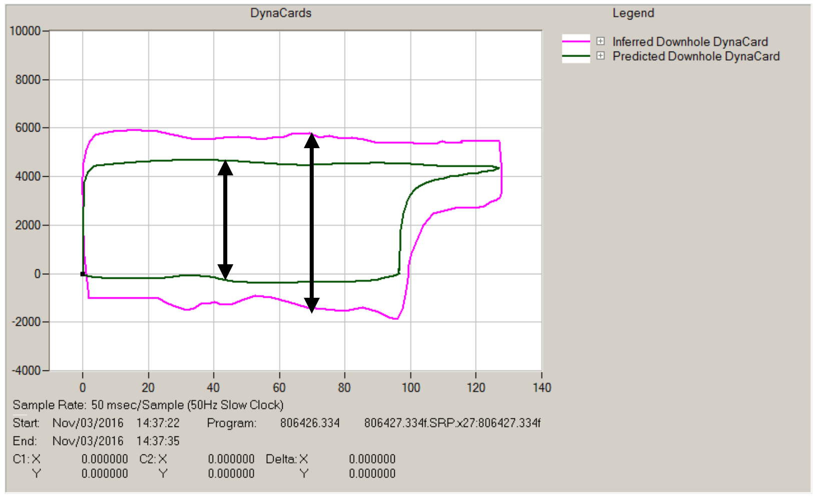
If the Predicted Surface Dynacard is lower than the Actual Surface Dynacard, then the modeled Rod Weight is too small.

Check setup parameters for rod lengths, diameters, and coupler type.

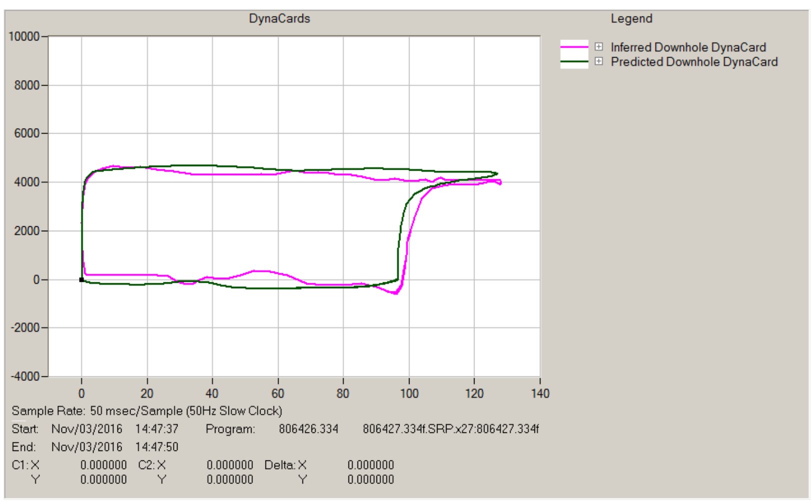
If necessary, the **rod weight offset** parameter can be adjusted to manually offset the Predicted rod weight (positive or negative). The **dynacard load offset** parameter can be used to manually offset the Actual rod weight (positive or negative).

Rod friction and stuffing box friction will also affect DynaCard position.

3.7 Actual Downhole DynaCard is Fatter than Predicted – Rod Friction is Wrong



Incorrect



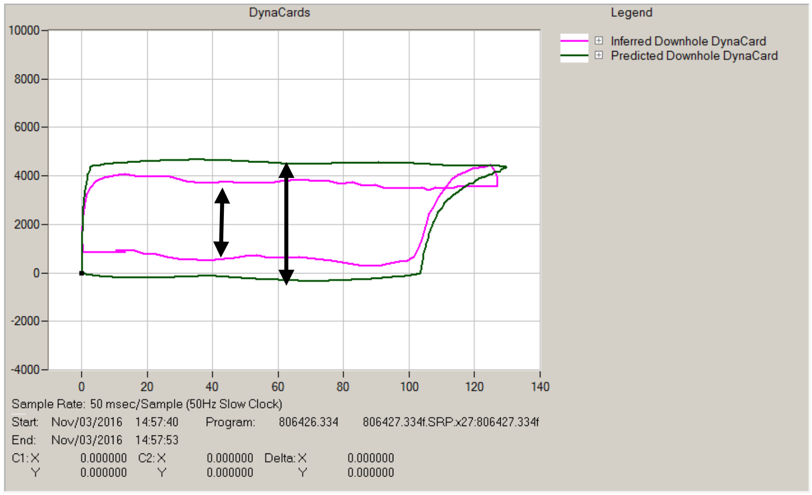
Correct ✓

75% pump fill example.

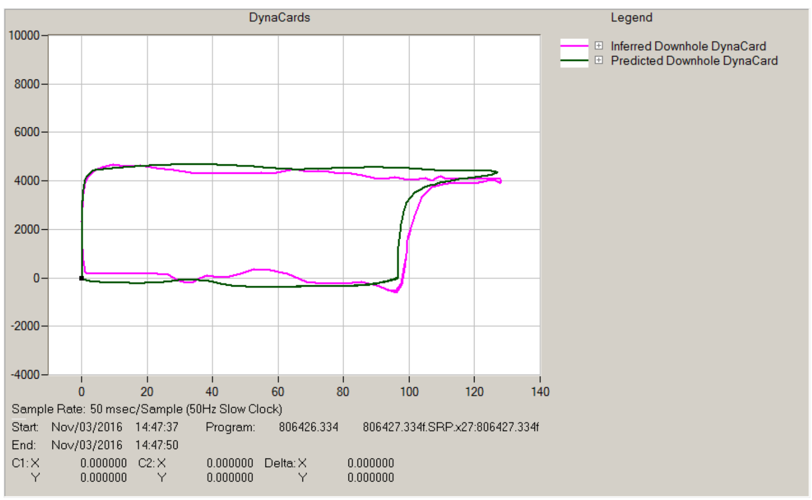
If the Actual Downhole Dynacard is fatter than the Predicted, then the Rod Friction is not being modeled correctly. The actual rod friction is more than the **rod friction** parameter.

Verify **plunger diameter**. Enable **auto rod friction enable**. Enable **auto rod frict pan**. Increase **rod friction** parameter.

3.8 Actual Downhole DynaCard is Thinner than Predicted – Rod Friction is Wrong



Incorrect



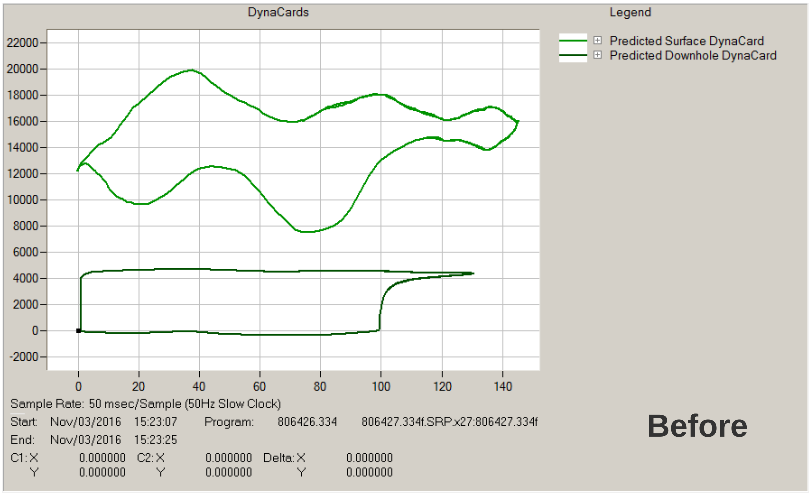
Correct ✓

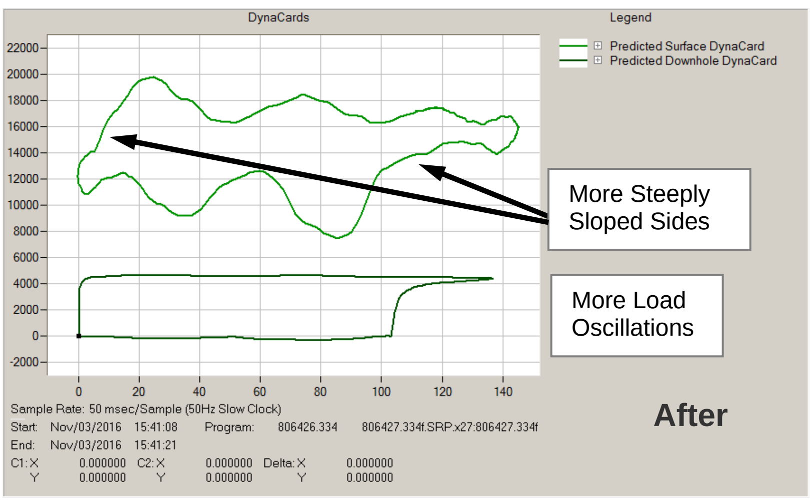
75% pump fill example.

If the Actual Downhole Dynacard is thinner than the Predicted, then the Rod Friction is not being modeled correctly. The actual rod friction is less than the **rod friction** parameter.

Verify **plunger diameter**. Enable **auto rod friction enable**. Enable **auto rod frict pan**. Decrease **rod friction** parameter. If Auto Rod Friction feature is enabled (and the Actual Downhole Dynacard is still too thin), then the **plunger diameter** is likely wrong.

3.9 Effect of Increasing “Rod Stiffness Gain” on Predicted Dynacards





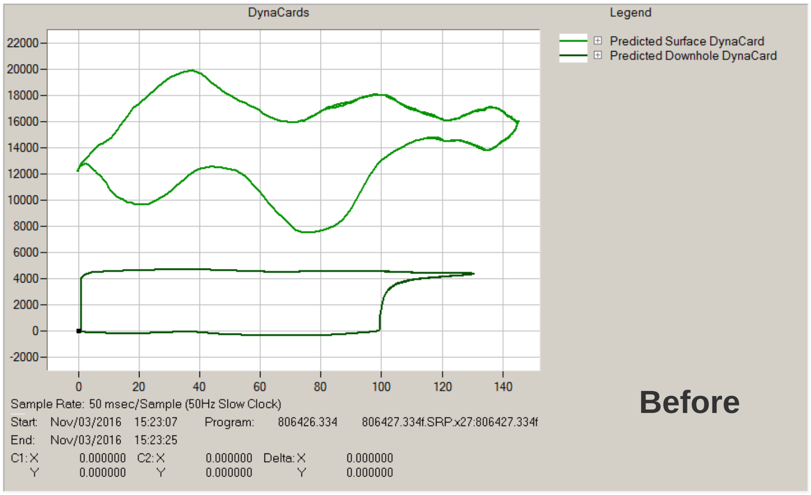
75% pump fill example.

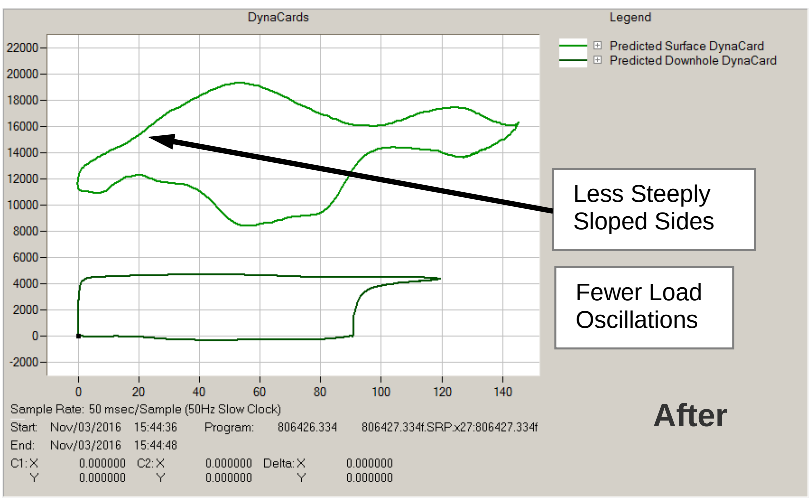
This illustrates the effect of increasing the **rod stiffness gain** parameter value.

Increasing the **rod stiffness gain** value increases (tilts up) the slopes of the sides of the predicted surface dynacard, and increases the number of rod load oscillations. Downhole pump stroke usually also increases.

The theoretically correct value for **rod stiffness gain** is 1.0.

3.10 Effect of Decreasing “Rod Stiffness Gain” on Predicted Dynacards





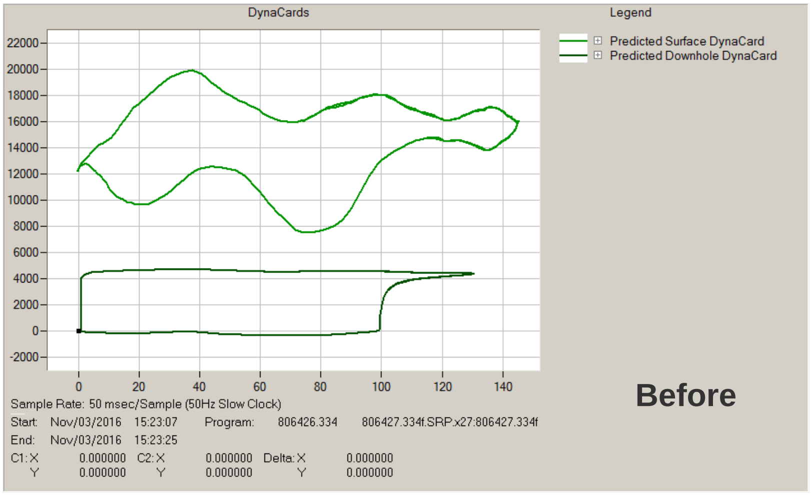
75% pump fill example.

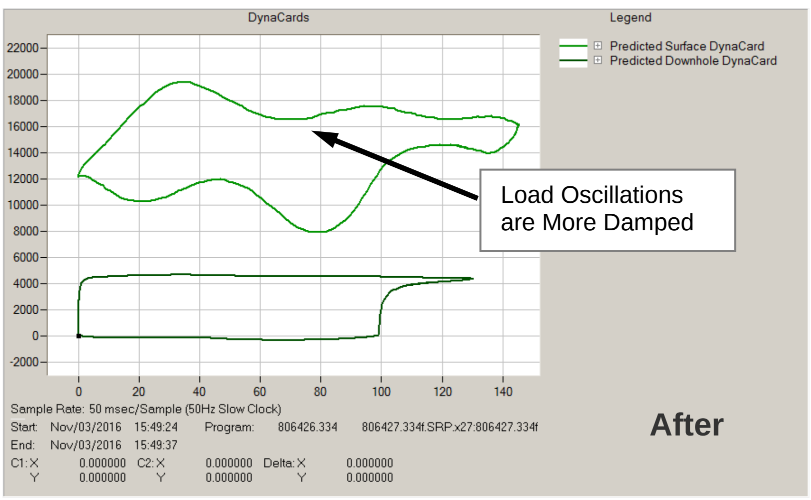
This illustrates the effect of decreasing the **rod stiffness gain** parameter value from 1.0 to 0.5.

Decreasing the **rod stiffness gain** value decreases (tilts down) the slopes of the sides of the predicted surface dynacard, and decreases the number of rod load oscillations. Downhole pump stroke usually also decreases.

The theoretically correct value for **rod stiffness gain** is 1.0.

3.11 Effect of Increasing “Rod Damping Gain” on Predicted Dynacards





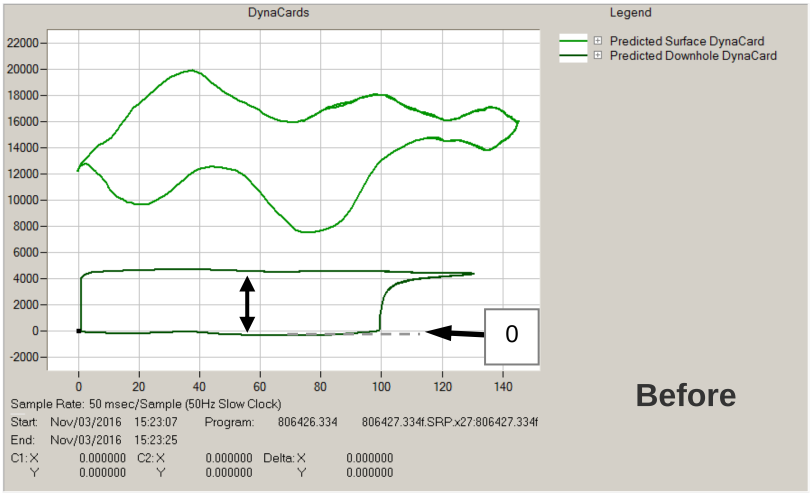
75% pump fill example.

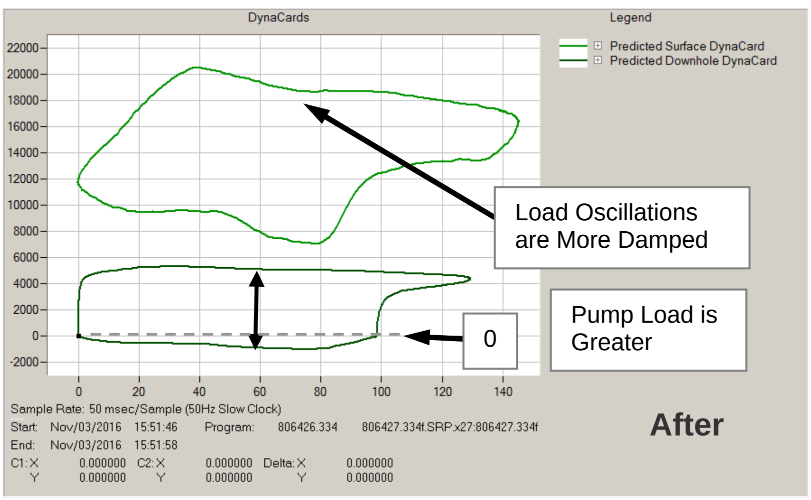
This illustrates the effect of increasing the **rod damping gain** parameter value from 1.0 to 10.0

Increasing the **rod damping gain** value reduces (dampens) rod load oscillations in the predicted surface dynacard.

This case is typically associated with deviated wells, or heavy oil.

3.12 Effect of Increasing "Viscous Friction Gain" on Predicted Dynacards





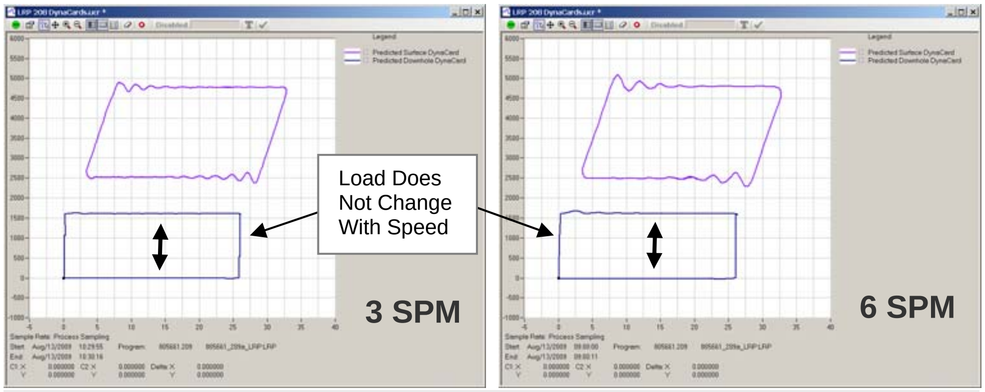
75% pump fill example.

This illustrates the effect of increasing the **viscous frctn gain** parameter value from 1.0 to 4.0

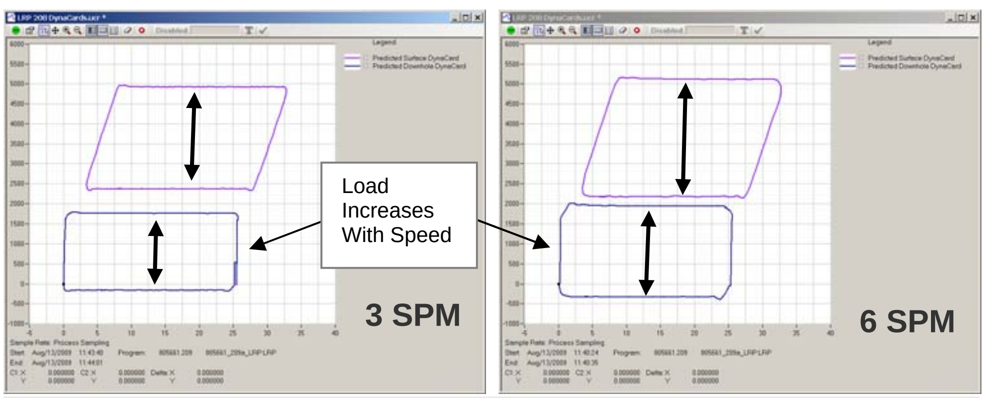
Increasing the **viscous frctn gain** value reduces (dampens) rod load oscillations in the predicted surface dynacard and increases the viscous pump load.

This case is typically associated with heavy and/or cold oil.

3.13 Effect of Increasing “Flow Friction Gain” on Predicted Dynacards



Before: Flow Frctn Gain = 0



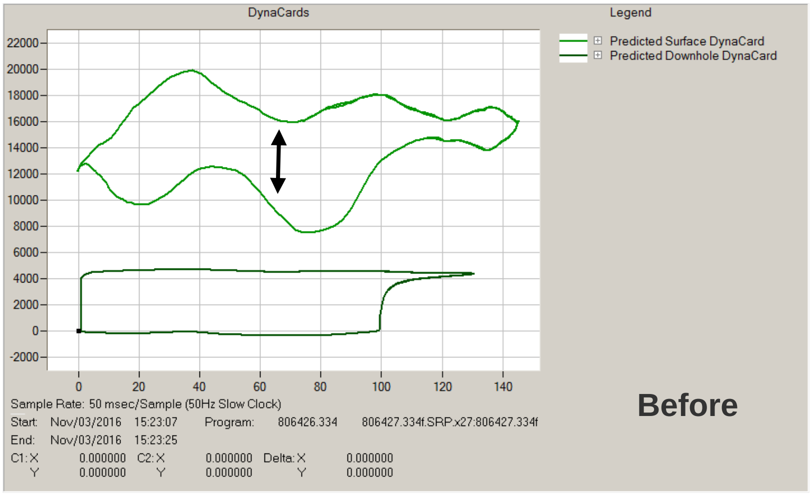
After: Flow Frctn Gain = 1

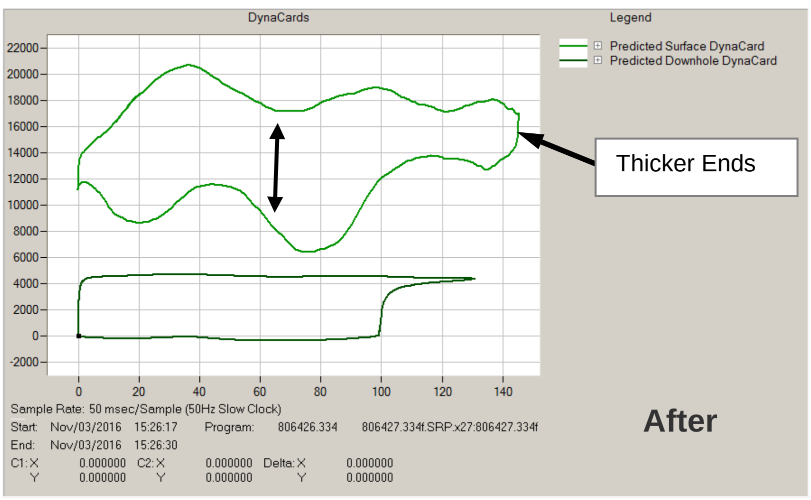
This illustrates the effect of increasing the **flow frctn gain** parameter value from 0 to 1.0

The **flow frctn gain** can be used to compensate for the effects of viscous flow line friction common with heavy oil production. If flow line friction causes the loading on actual dynacards to increase with speed, the **flow frctn gain** should be adjusted to match predicted loading to actual loading. (Adjust **flow frctn gain** until predicted and actual dynacards match throughout the speed range.)

Increasing the **flow frctn gain** value causes predicted surface and downhole dynacard differential loads to increase with speed. It also reduces (dampens) rod load oscillations in the predicted surface dynacard.

3.14 Effect of Increasing "Stuffing Box Friction" on Predicted Dynacards





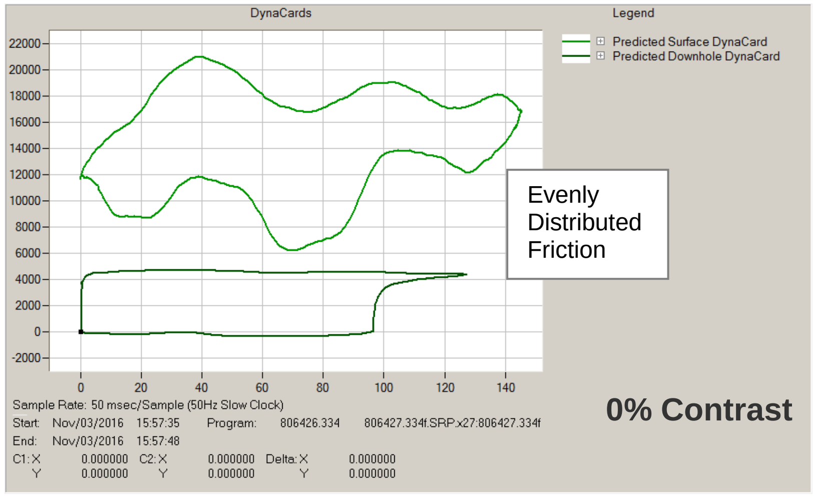
75% pump fill example.

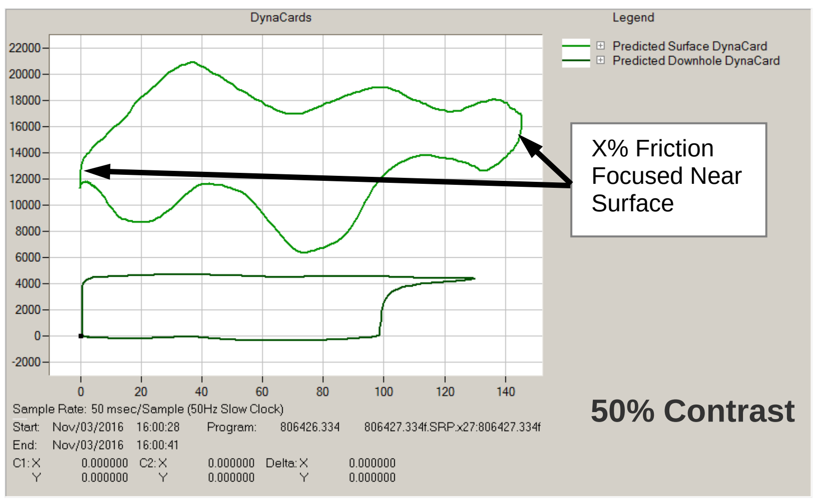
This illustrates the effect of effect of increasing **stuff box friction** parameter.

Increasing the **stuff box friction** value fattens the Predicted surface dynacard, and creates flat, vertical sides as shown. The Predicted downhole dynacard and pump stroke remain unchanged.

Decreasing the **stuff box friction** value has the opposite effect.

3.15 Effect of Changing “Rod Friction Contrast” on Predicted Dynacards





75% pump fill example.

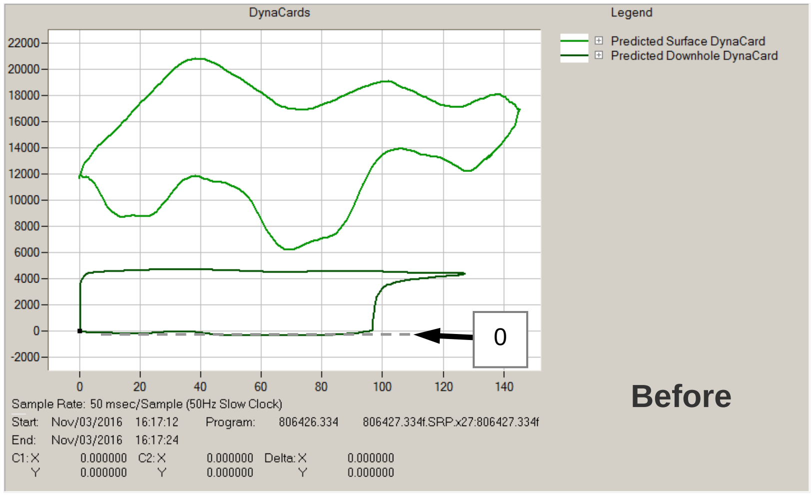
This illustrates the effect of changing **rod frct contrast** parameter from 0% to 50%. The ends of the Predicted surface dynacard will be fattened (but the middle will remain the same).

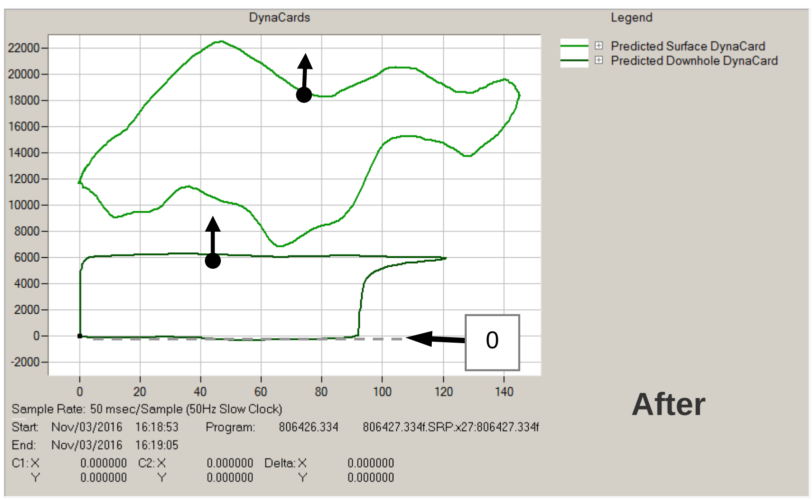
The **rod frct contrast** value allows the rod friction distribution to be modified. At 0%, the rod friction is distributed evenly along the entire rod string. This is suitable for straight, vertical wells, or for wells with gentle, deep deviations. As **rod frct contrast** percent is increased, that percentage of friction is focused more near the surface, as may be the case on some wellbores such as S bore.

With **rod frct contrast** equal to100%, the rod friction is focused entirely at the surface. For wells with highly located deviations (were most of the friction is closer to the surface), the **rod frct contrast** should be larger.

The **rod frct contrast** may also be used to correct for stuffing box friction. The advantage of using **rod frct contrast** over **stuff box friction** parameter is that the Auto Rod Friction feature will perform better – Auto Rod Friction has auto correction for the contrast compensation, but not for the stuffing box term.

3.16 Effect of Increasing “Plunger Diameter” on Predicted Dynacards



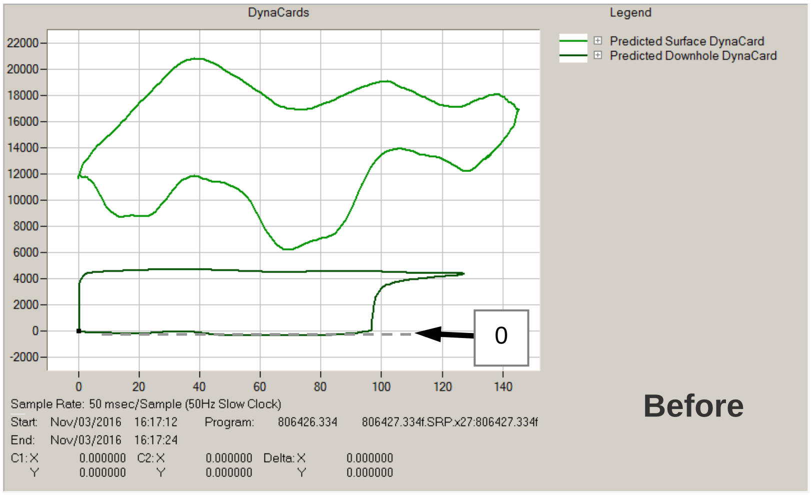


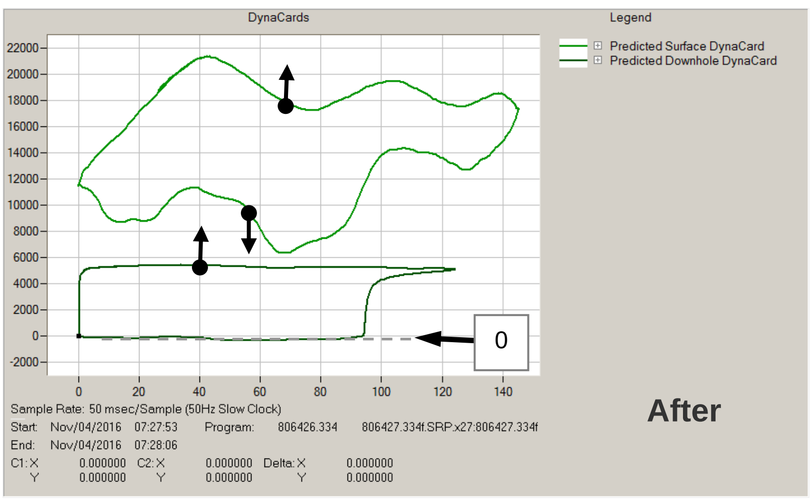
75% pump fill example.

This illustrates the effect of increasing the **plunger diameter** parameter from 1.5 to 1.75 inches.

Increasing the value of **plunger diameter** parameter causes both the predicted surface and predicted downhole dynacards to be fatter. The upstroke load increases, but the downstroke load remains unchanged (buoyant rod weight does not change).

3.17 Effect of Increasing “Water Specific Gravity” or Reducing “Oil API Density” Value





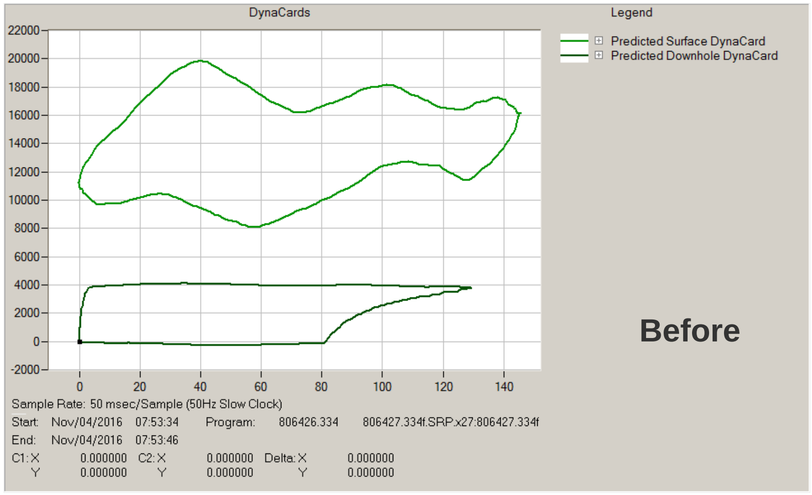
75% pump fill example.

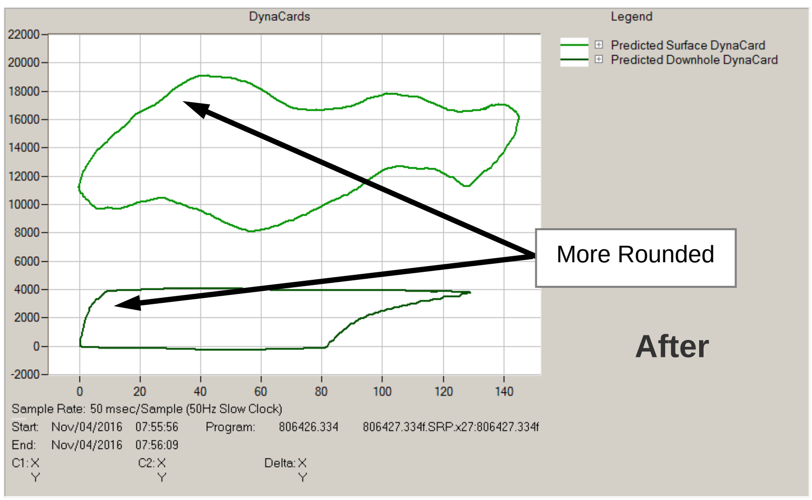
This illustrates the effect of increasing the value of **water specific gravity** parameter, or decreasing the value of **oil gravity** parameter in API units

Increasing the fluid density causes both the predicted surface and predicted downhole dynacards to be fatter. The surface and downhole upstroke load increases (because the load is heavier), and the surface downstroke load decreases (because of additional rod buoyancy). The downhole downstroke load remains unchanged.

Note that fluid density can be affected by the presence of gas in the tubing.

3.18 Effect of Increasing "Pump Bottom Spacing" on Predicted Dynacards



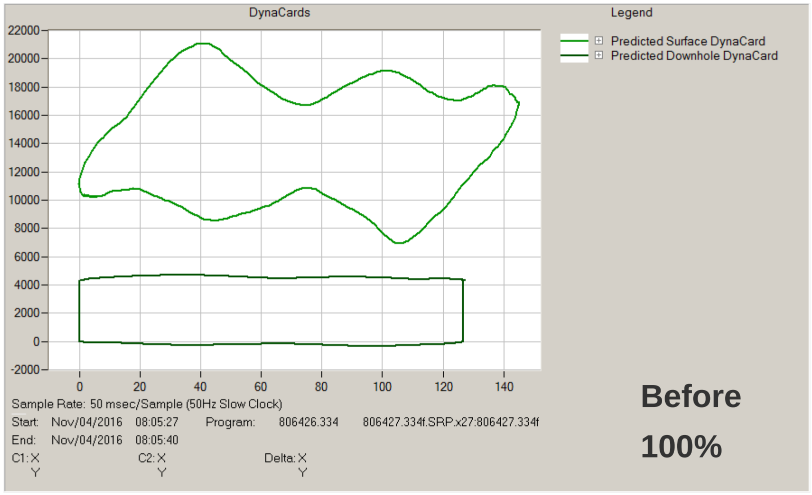


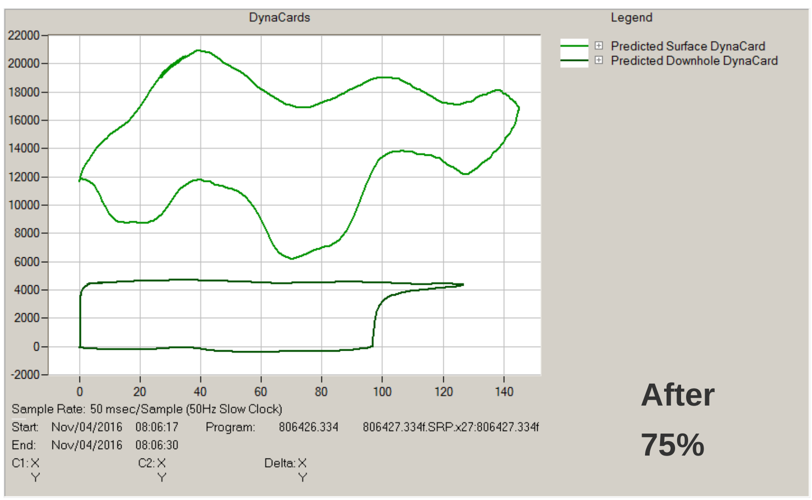
75% pump fill example.

This illustrates the effect of increasing **pump bottom spacing** parameter from 8 to 24 inches.

Increasing the **pump bottom spacing** value causes gas to expand at the start of the upstroke, delaying the closing of the traveling valve, thereby simulating "gas interference." The **pump bottom spacing** parameter is the distance between the bottom of the pump and the standing valve when the pump is at its bottom-most position in the stroke.

3.19 Simulating Incomplete Pump Fill on Predicted Dynacards





This illustrates the effect of changing **simulated pump fill** from 100% to 75%

Oftentimes the pump is 100% full at start-up. It is possible to simulate incomplete pump fill (as if the well were pumped off) by introducing a **sim liquid fill** value to the Predicted dynacards. Set **sim liquid fill** to the desired liquid pump fill simulation.

NOTE: **Fill simulation mode** must be set to KEYPAD to allow the **sim liquid fill** parameter to be changed. If **fill simulation mode** is set to AUTO, the **sim liquid fill** value will be automatically set equal to the **pump fill monitor** value.

After the pump fill simulation is complete, set **fill simulation mode** back to AUTO!