MV User Manual

VERSION HISTORY

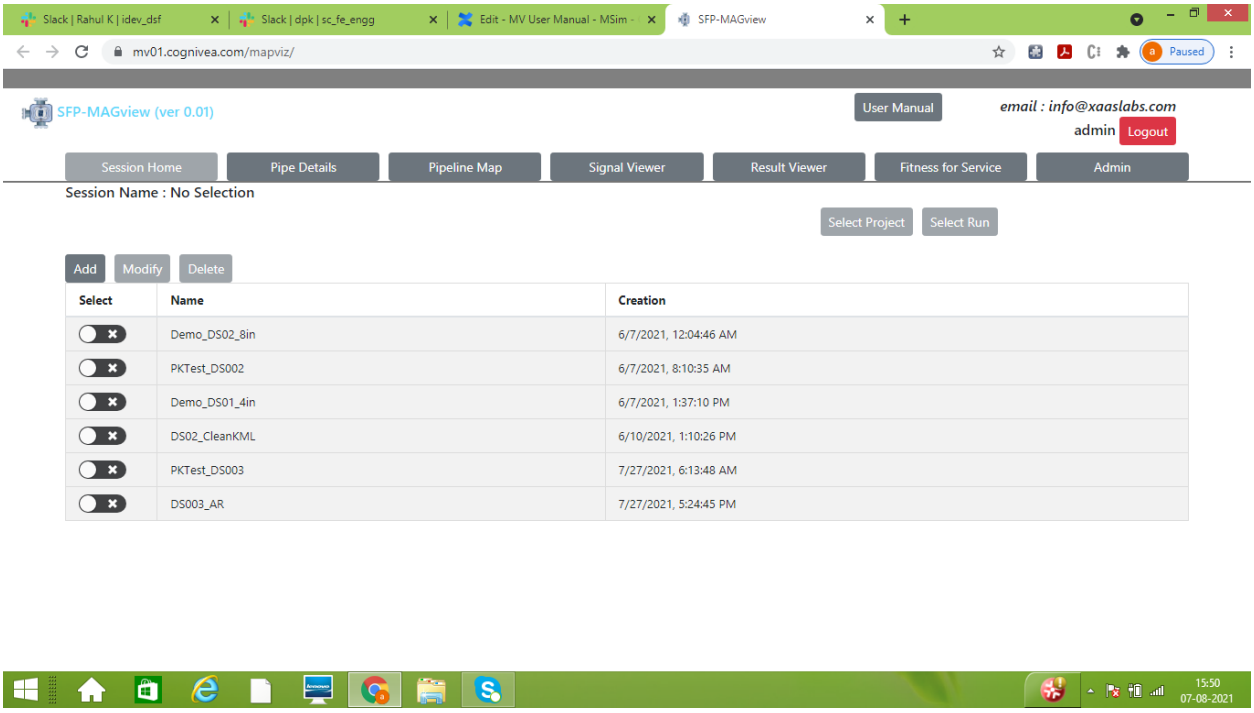
Version #	Implemented By	Revision Date	Approved By	Approval Date	Reason
0.01	*AR*	*<06/01/21>*	PK	*<06/02/21>*	Current Draft
0.02	*AR*	*<08/06/21>*			Minor Edits
0.03	AR	<10/09/21>			Update Pipe Details
0.04	AR	<10/20/21>			Update for SI units and X,Y,Z data analysis
0.05	AR	<11/07/21>			Update Section for Run Comparisons
0.06	AR	<07/27/22>			Add details about KML point insertions and definitions

This document describes user flow and menu items of the MagView application. The MagView application allows a user to input Sensor readings, Geo-location data in KML format and Pipeline Segmentation data and then automatically pre-processes the data to provide the user areas where there could be defects. The defects are identified through pluggable, user-provided functions. Current version of MagView supports Magnetometer sensor readings only. The application consists of a backend module coupled with a Postgres database for storing values and results. Front-end is based on Javascript.

Instructions

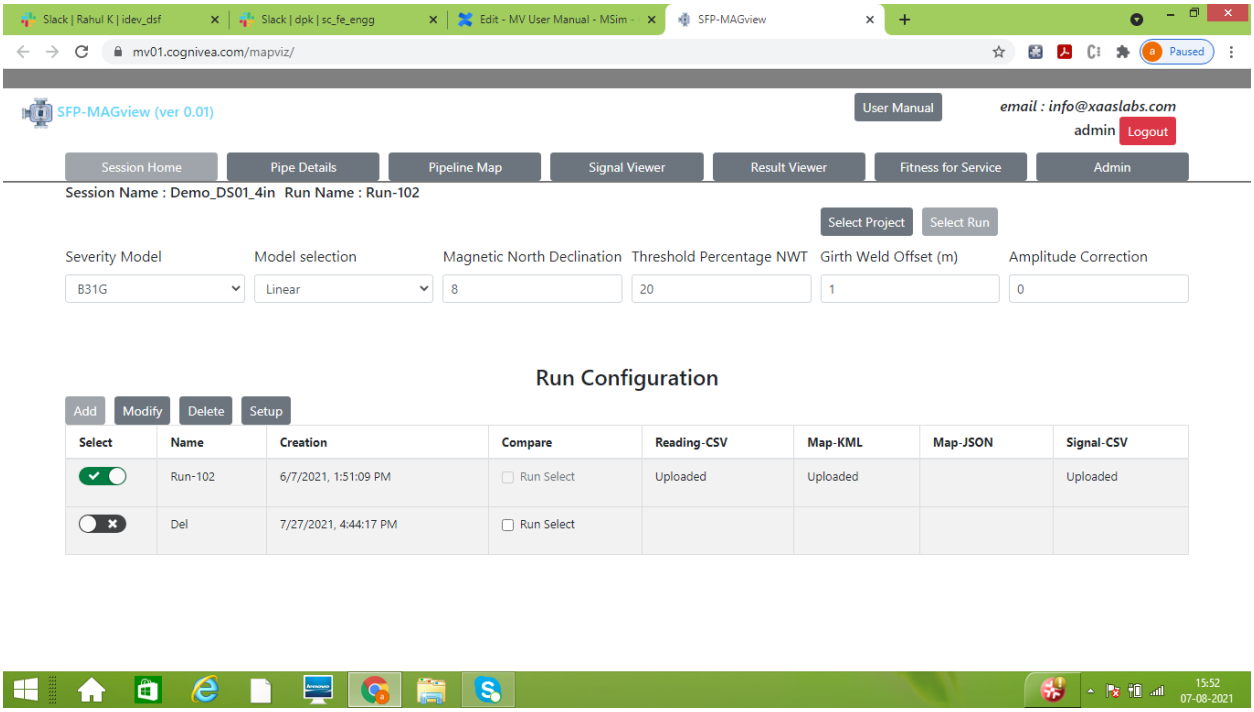
Create a New Session

Create a new project after successfully logging in to the application. Click the ‘Add’ Button to create a new project.



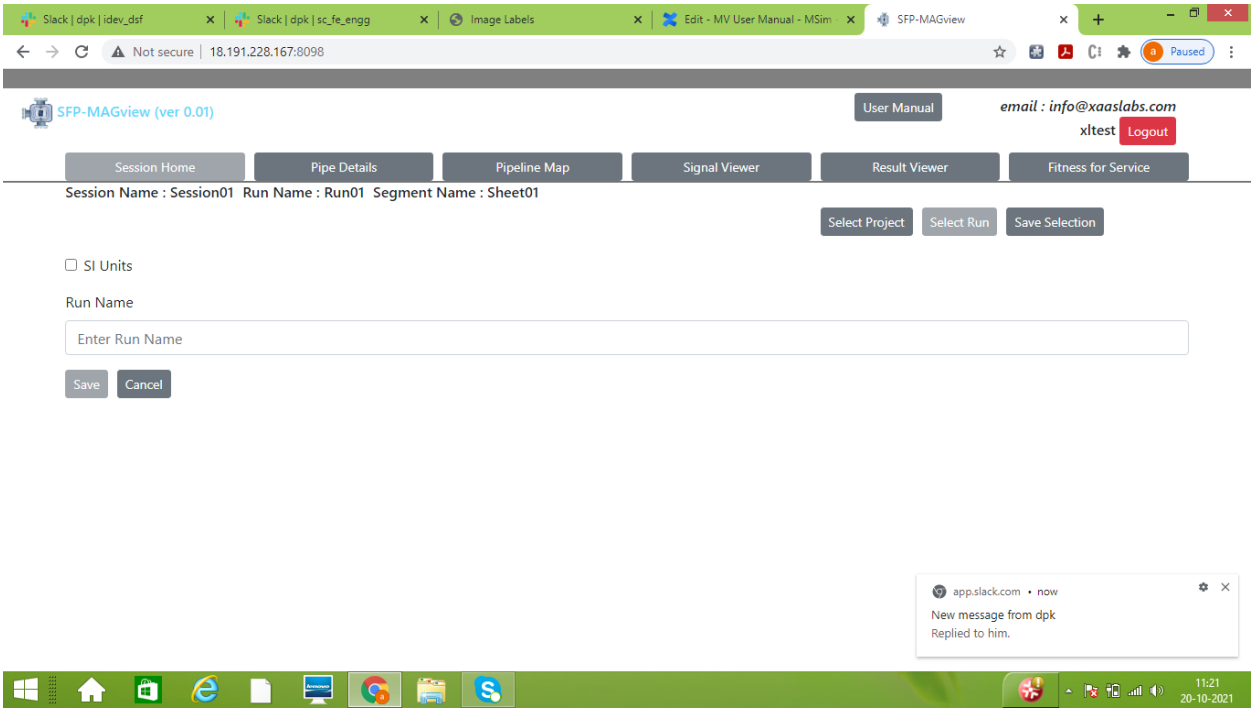
Enter a name for the ‘Session Name’ and click ‘Save’. You should then see the same screen as above with your newly created session. For the purpose of this document, we created a session named ‘Demo_DS1_4in’.

Select the newly created session and click the 'Select Run’ Option. This will bring up a screen that requires you to upload project related files such as Magnetometer readings, KML files and Girth Weld Files. Magnetometer and Girth Weld files are expected to be in CSV format only. (Refer to Appendix 1 for details about the format of these files)

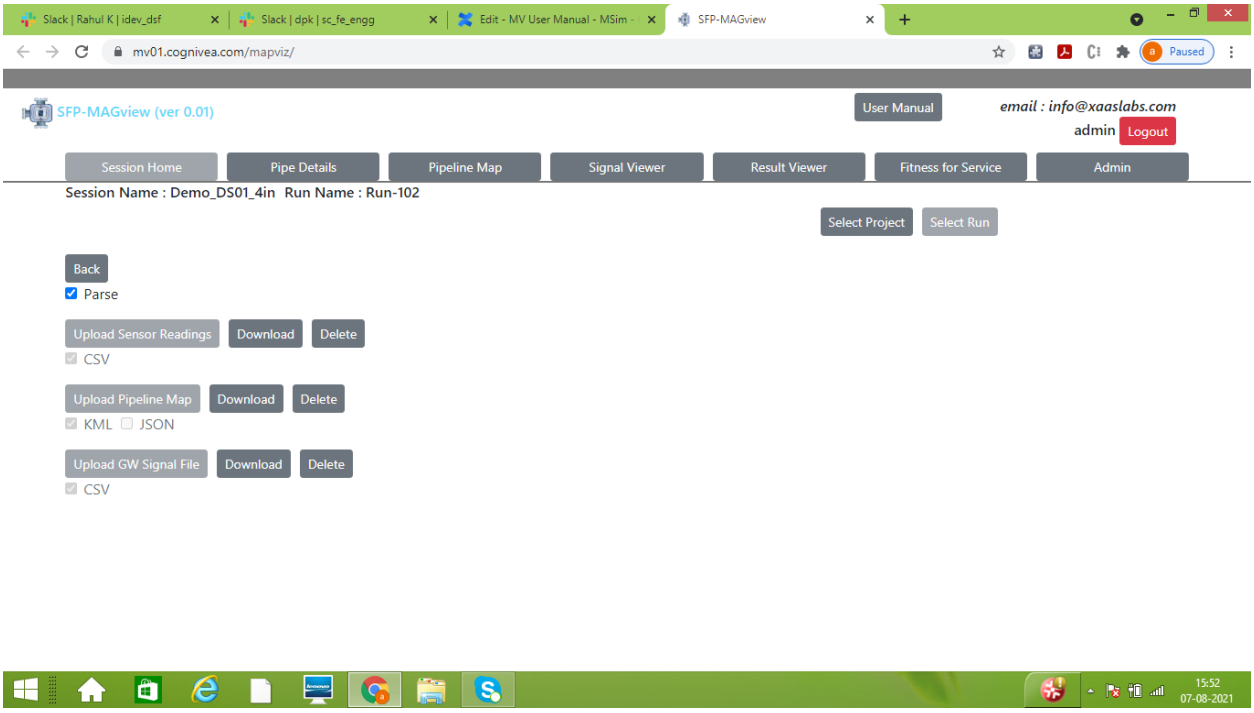


Click ‘Add’ to create a new ‘Run'. Each Run represents an inspection cycle. A ‘Session’ represents a Pipeline Asset. So a ‘Session’ may have multiple ‘Runs’ associated with it. In this screen, there is an option to select the units of measurement for the data. Check this box in case the data and subsequent analysis will be done in SI units. Default is Imperial units.

The user can also compare the signals of one run against the other by selecting the ‘baseline’ run from the ‘Select’ Column and the to be compared run from the ‘Compare’ column check box. Currently only two runs can be compared. The signal comparisons can be viewed in the 'Signal Viewer’ tab by using clicking the Compare button.



Give a name for this particular Run when prompted and click the ‘Save’ Button. The newly created run will be available in the screen menu above. Select the Run and click ‘Setup’ to add files.



In this menu, you will have the option to upload files. You may keep the default selections and use the individual ‘Upload…’ buttons to upload the files to the system. Hit the ‘Back’ to go back to the ‘Run’ Menu.

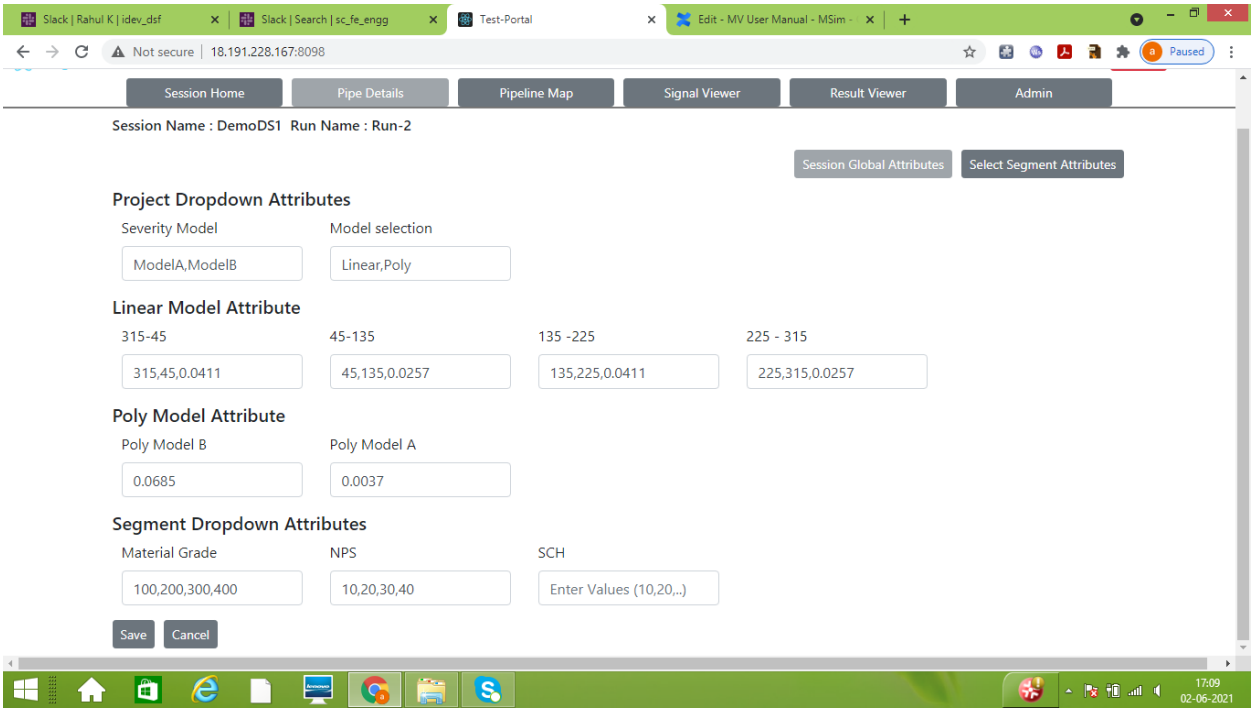
Note: Please leave the Parse button checked (by default it is checked). The Parse button decides whether the utility pre-processes the uploaded data before storing into the database for quicker retrieval in later stages. If it is left unchecked, the raw files are stored as they are and are not suitable for further computations.

Note: Depending on the size of the files and the server load, it could take several minutes for the files to be uploaded and processed.

In the 'Select Run', you also have the option to set Run specific parameters such as

- Severity Model - Select either the B31G or the Modified B31G (B31G-M) model for Fitness for Service.
- Model Selection - Either of ‘Linear’ or ‘Poly’. The attributes of these parameters are set later.
- Magnetic North Declination - Can be entered by the user for this ‘Run’
- Threshold Percentage NWT - When calculating severity, any value less than this threshold shall be represented differently from values greater, typically, in a different color.
- Girth Weld Offset - By default, a distance of +/- 1m (3.3ft) around a girth weld is excluded from measurements. This distance can be adjusted in this menu.
- Amplitude Correction - The calculated severity percentages can be adjusted using this parameter.

Click the 'Pipe Details' Menu button and then select the 'Session Global Attributes’ button to enter Project Attributes for this project.

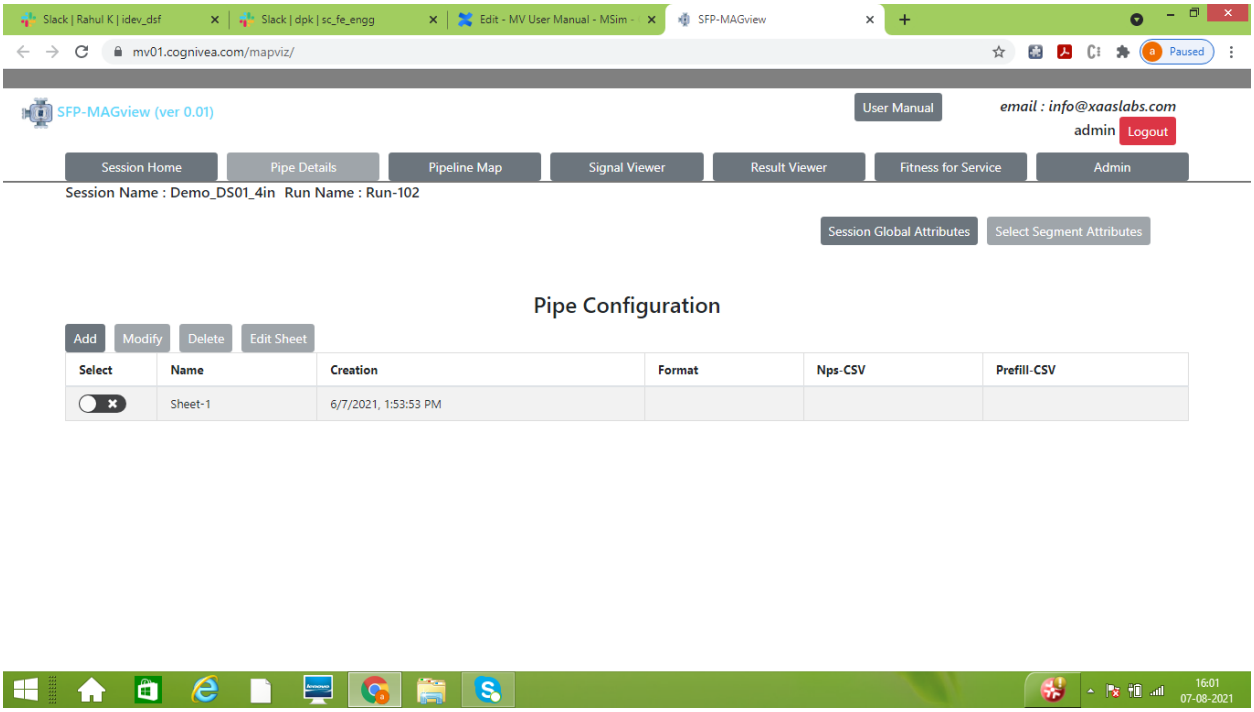


The fields are as follows

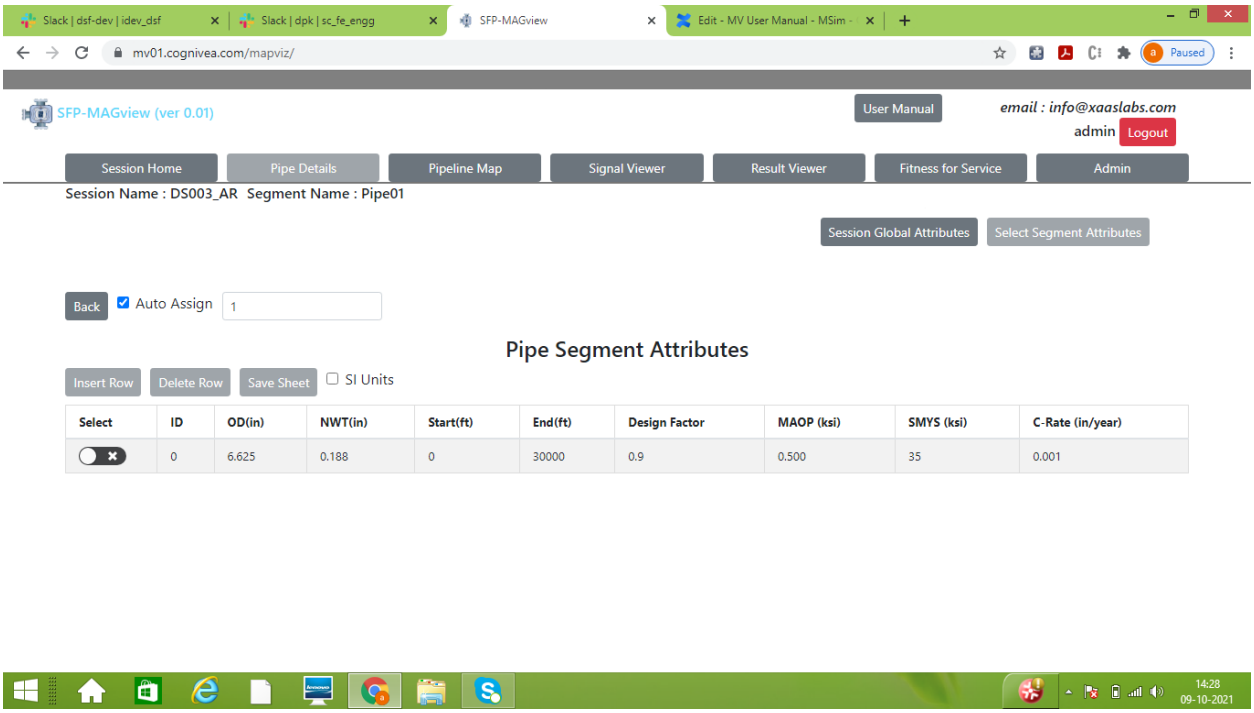
- Severity Model - Currently Unused
- Model Selection - Enter 'Linear,Poly' as supported models
- Linear Model Attribute - Currently 4 direction buckets are defined. Enter each field under the bucket in the format { Start Bearing, End Bearing, MH Linear Constant Value }
- Poly Model Attribute - Enter the ‘B' and 'A’ Value in the appropriate field
- Segment Dropdown Attributes - Enter the Material Grade and NPS values used in this pipeline as a comma separated list.

The values entered in this menu are used and available in other menus of the program. Hit the ‘Save’ button to save these settings.

Click the ‘Select Segment Attributes’ Button in the sub-menu to bring up a page where you will be required to enter design details of the pipeline.



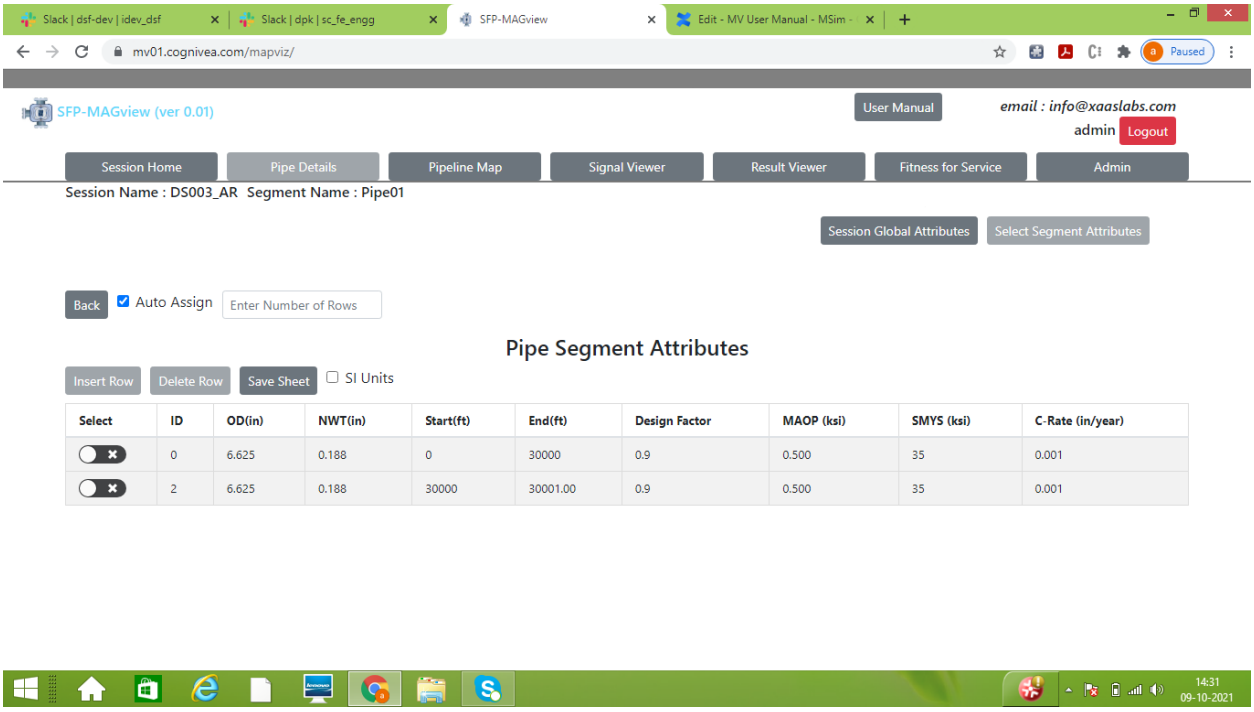
Now, click ‘Add’ to enter the Segment attributes. Enter a name for the segment and click save. The newly created segment will be available in the menu. Select the segment and click ‘Edit Sheet’ to start entering details of the pipe.



Select the first row and enter details of the pipe segments

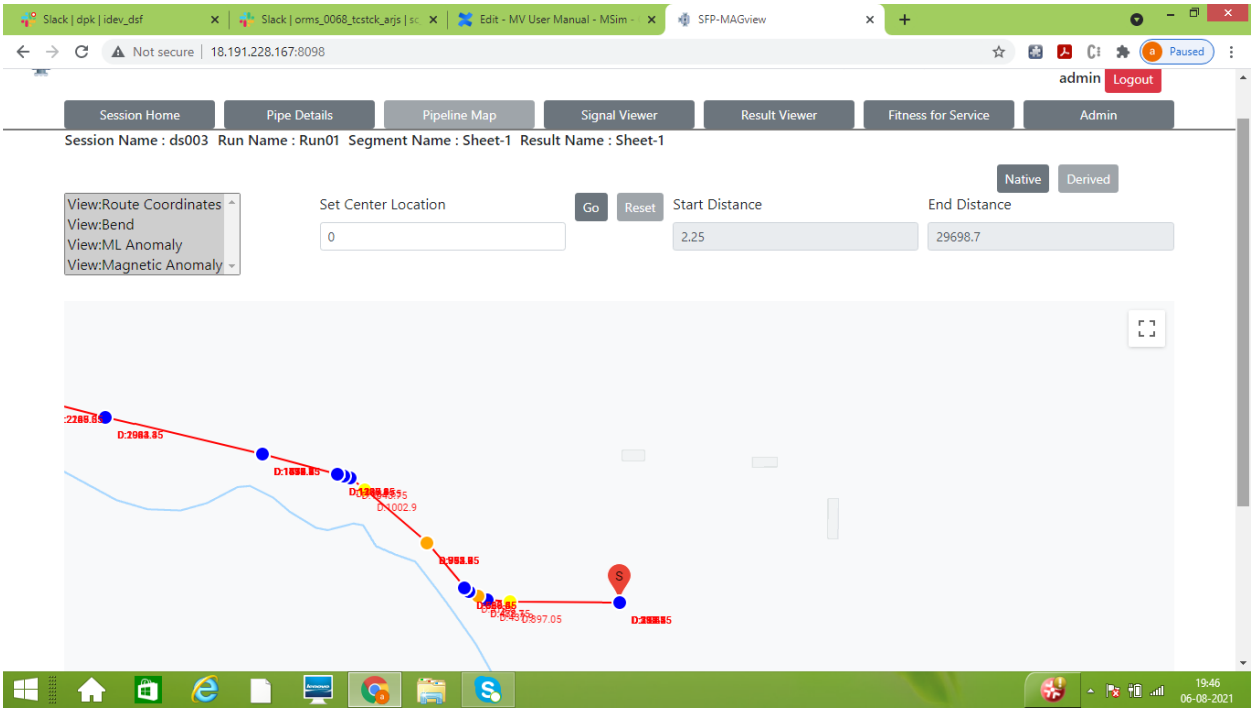
- ID - Can be any identifier for the pipe segment
- OD - Enter the value of the Outer Diameter of the Pipe Segment
- NWT - Enter the value of the Nominal Wall Thickness of the Pipe Segment
- Start , End - Enter the starting and ending offsets for the pipe segment in feet
- Design Factor, MOP(ksi), SMYS and Corrosion Rate - Values can be entered here.

Data can optionally be entered in SI units by selecting the SI Units option in the checkbox. You can enter multiple rows for successive pipe segments by clicking the ‘Insert Row’ Button. If Auto - Assigned is checked, the option ‘Insert Row’ automatically adds the number of rows entered with most values pre-filled with the preceding row's data, particularly, the Start value which is filled with the previous row's End value to maintain continuity. Once all entries are saved, click the ‘Save Sheet’ to save the values.



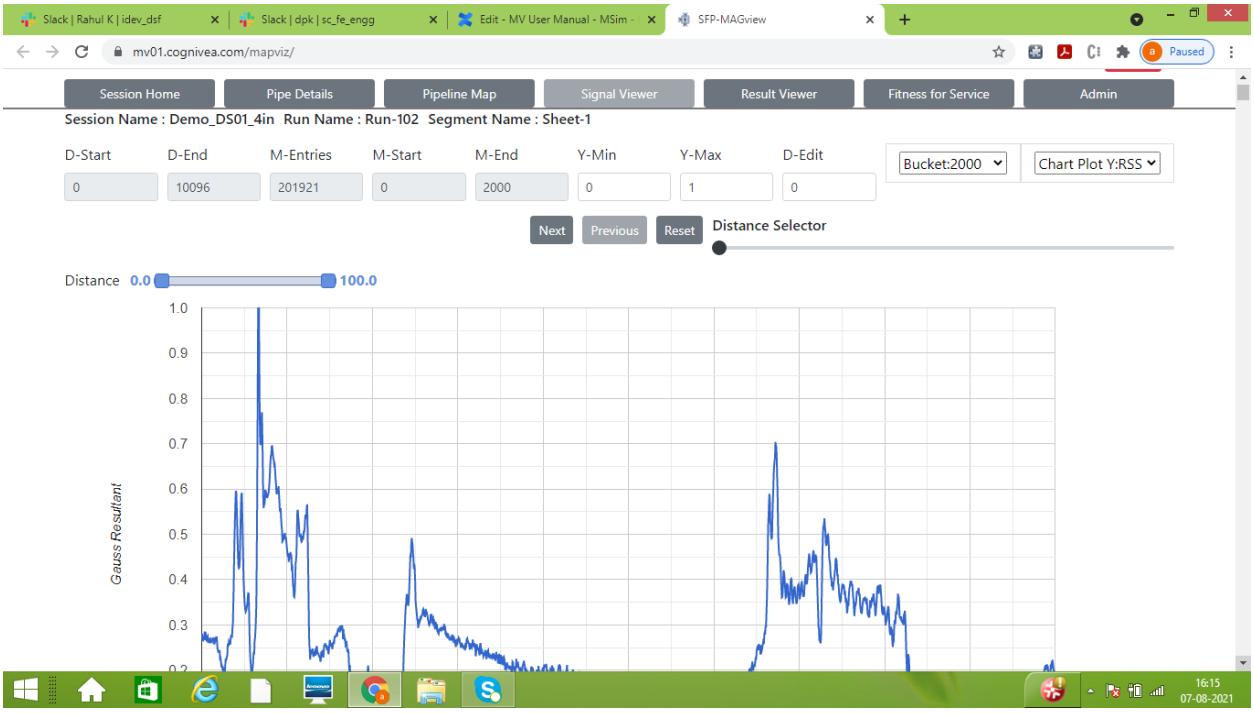
Viewing the Data

In the Pipeline Map menu, one can view the KML as was uploaded by the user



The view shows the length of the pipe from start to end. Against each coordinate in the KML, a cumulative distance from start to that coordinate (in feet) is also printed. If the Results sheet has been computed and selected, this screen provides the user two options - Native and Derived Views. The Native View option shows the points and paths as specified in the KML. The Derived View shows points and paths as derived from the Results Sheet. In this view, girth welds, bends, ML and Magnetic Anomalies are shown in different colored markers and a filter is available to display only markers of interest. The user can also set a distance parameter to jump to a particular location on the path. The map will center on the point nearest to the set distance as per the Results sheet. A valid paid Google Maps account is needed for the map to display properly.

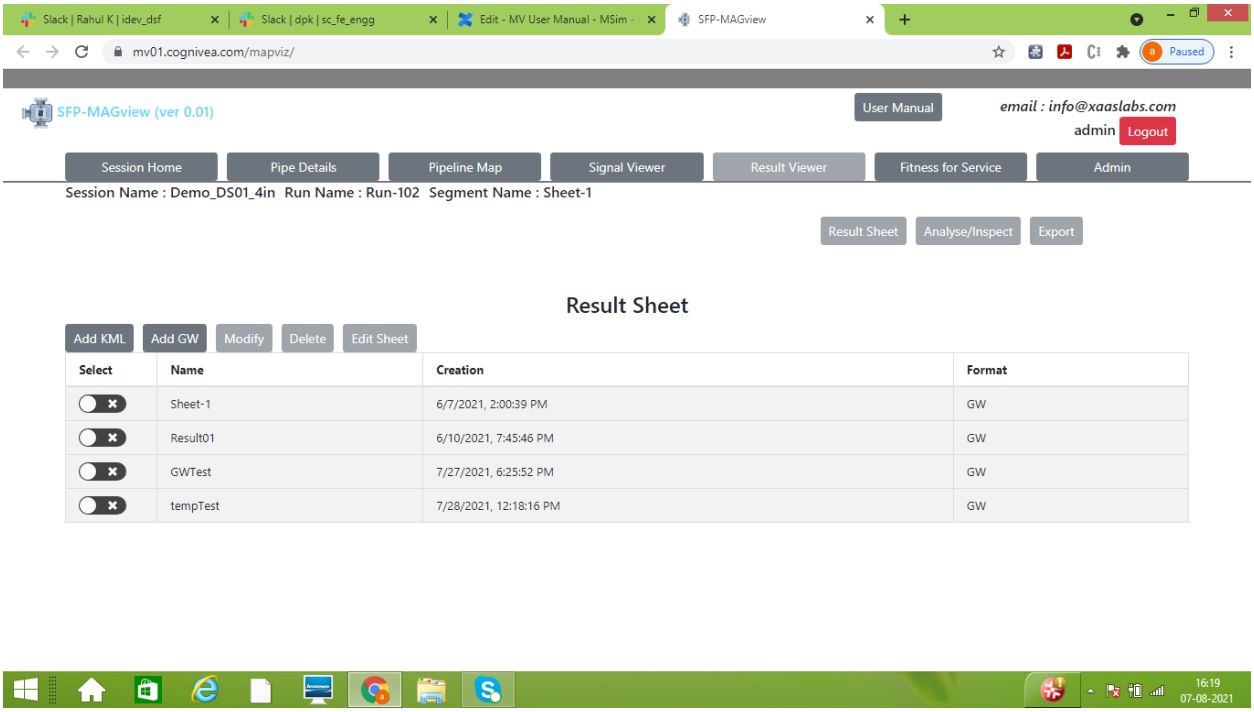
Under the Signal Viewer menu, the user can view the measurements readings in graphical format. Depending on the data size, it may take some time to load the measurements and plot the graph.



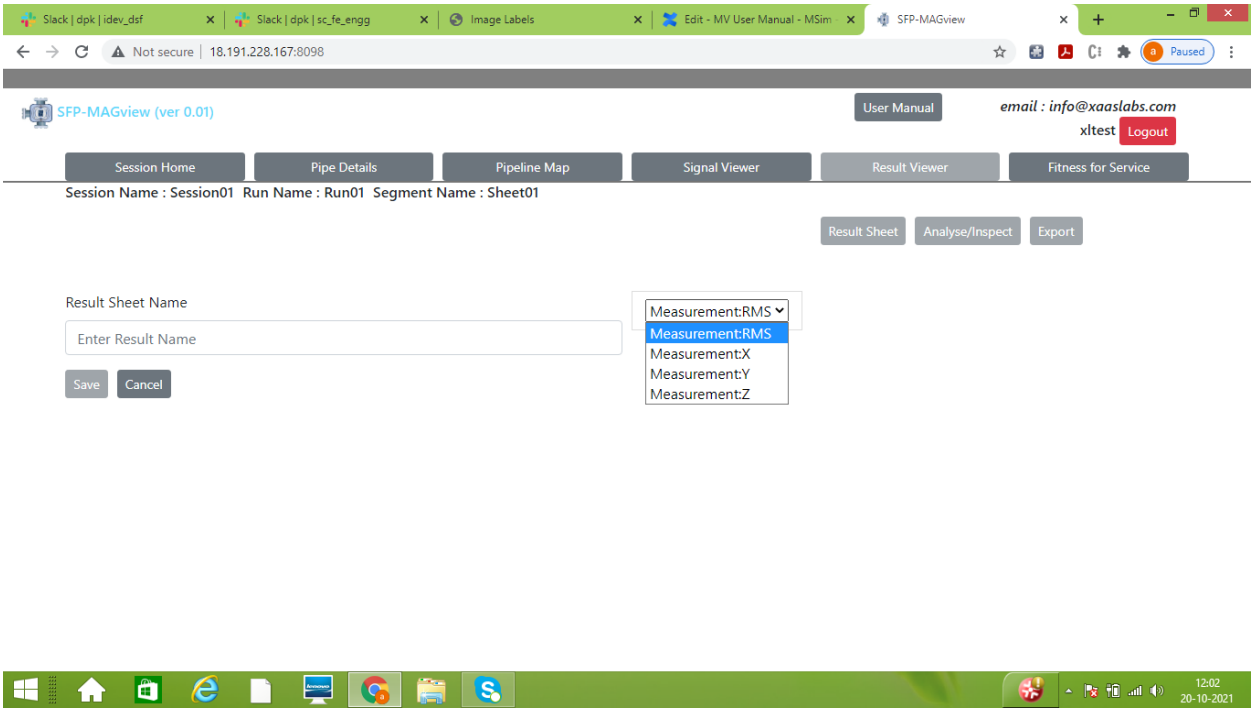
The graph plots ‘Resultant Gauss’ vs ‘Distance’ . Using the menu below one can set the number of entries to load at a single time. The utility displays the selected number of entries in the graph at a time and the user can navigate to the next/previous graph slices using the Next and Previous buttons. Within a slice, the user can zoom in by adjusting the ‘Distance’ slider. The user can also select a Distance to center the plot by using the Distance ‘Slider’. Once the center is selected, press ‘Reset’ to fetch the relevant plot. Y-Axis range can be adjusted using the Y-Min / Y-Max options.

Processing the Data

After all the required data has been entered, the user can go to the ‘Results’ menu by clicking the ‘Result Viewer’ button



The user has an option to select girth weld offsets by using either the girth welds CSV or the KML. In the case of KML, each coordinate in the KML is deemed to be a Girth Weld. We will use the girth weld CSV by clicking the 'Add GW' menu.

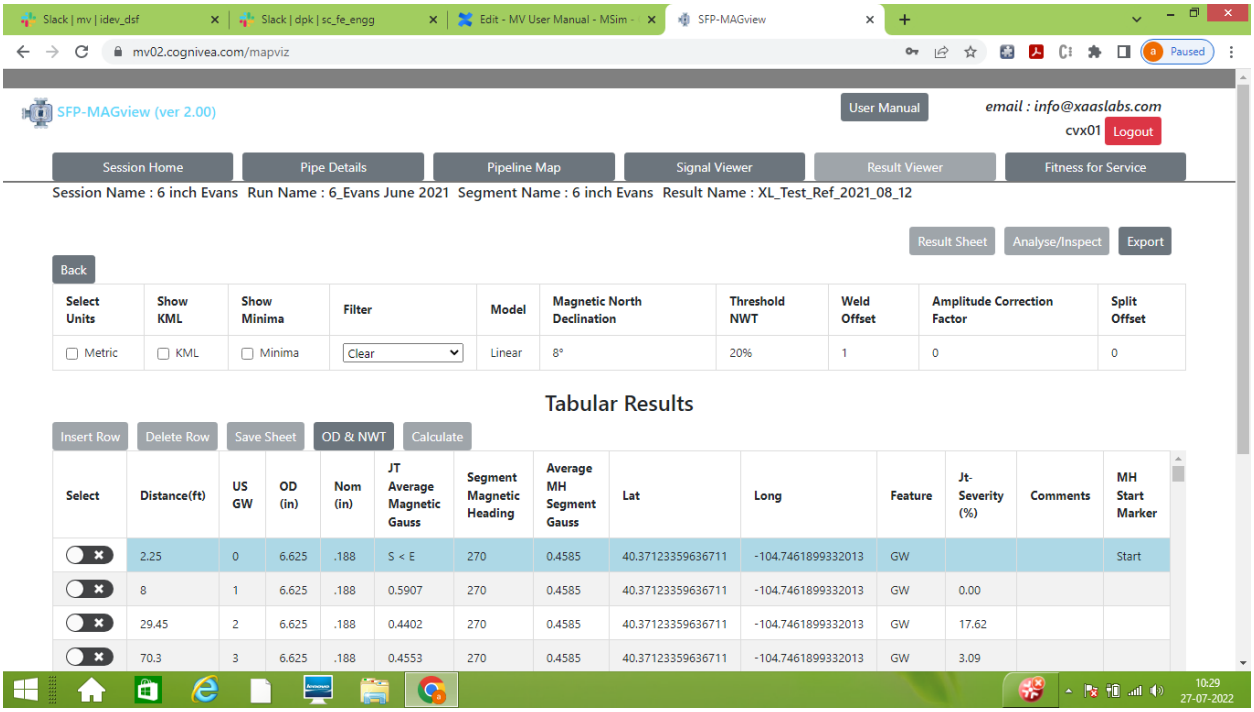


One can select which measurement series is to be used for subsequent analysis in this Run. By default, the RMS value is selected, but one can select X,Y or Z direction signals as well.

Enter a name for the Result Sheet and click ‘Save’. As before, pre processing the CSV and its data might take some time depending on the size of the CSV.

The newly generated Result Sheet should now be available for selection. Select the result sheet from the table and click ‘Edit Sheet’

If needed, one can view all parameters in SI units by clicking the SI Units Checkbox.



A result table is available with the following columns. Certain values are pre-computed as below

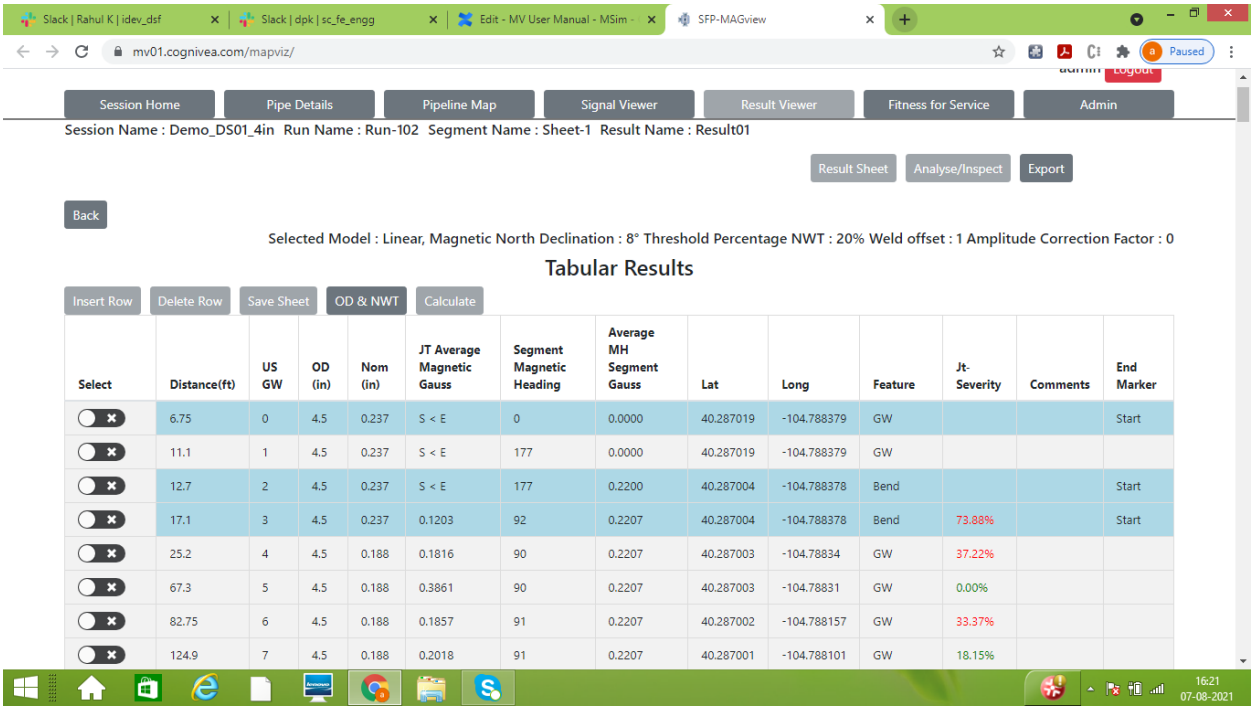
- Distance (ft) - The initial values are picked from the girth weld CSV. For each entry pair that identifies a pipe joint,
    - The measurements (sensor) data starting from the upstream offset + 3.3 feet to the downstream offset - 3.3 feet is retrieved and the offset with the minimum resultant gauss reading stored for later analysis. For short joints (less than 6.6 feet) or for which no measurement readings are available, minima are not computed. The offset value is configurable through the Girth Weld Offset parameter
- US GW - This is an automatically generated ID for the girth weld.
- OD and NWT can be prefilled using the ‘OD and NWT’ button. This can only be done if the segment section under Pipe Details were filled. The application looks for the row in the segment details table where the girth weld offset lies with the ‘Start’ and ‘End’ values and picks up the OD and NWT values accordingly.
- JT Average Magnetic Gauss - Average value for each joint is automatically computed using the measurements data available when calculating the 'Distance' column above. (Sensor readings from upstream offset + 3.3 feet to downstream offset - 3.3 feet)

- Latitude, Longitude and Segment Magnetic Heading - These are filled up by looking up the girth weld offset value in the cumulative distance computed from an uploaded KML file. The nearest coordinates in the KML are used to calculate the heading (bearing) of the pipe joint. The value thus computed is entered into the Segment Magnetic Heading column.
- For all rows inserted by the user, due to their being ‘minima’ and thus potential defect / anomaly locations, the values of the immediately preceding row are entered automatically.

Session Attributes are shown above the table.

- The 'Show KML' option interleaves GW or Bends as identified by the KML file into the result sheet. These are inserted as extra rows labelled in the feature column as KML-B for bends in the KML map and KML-P otherwise.
- The ‘Minima’ option will show the magnetic minima rows
- The Filter option allows the user to see only specific features that are either computed or labelled by the user, such as Bends, Magnetic or ML Anomalies among others.

Finally, click ‘Calculate’ to compute segments, segment averages and severities based on the the selected ‘Severity Model’ (Linear, Poly)



Select	Distance(ft)	US GW	OD (in)	Nom (in)	JT Average Magnetic Gauss	Segment Magnetic Heading	Average MH Segment Gauss	Lat	Long	Feature	Jt-Severity	Comments	End Marker
	6.75	0	4.5	0.237	S < E	0	0.0000	40.287019	-104.788379	GW			Start
	11.1	1	4.5	0.237	S < E	177	0.0000	40.287019	-104.788379	GW			
	12.7	2	4.5	0.237	S < E	177	0.2200	40.287004	-104.788378	Bend			Start
	17.1	3	4.5	0.237	0.1203	92	0.2207	40.287004	-104.788378	Bend	73.88%		Start
	25.2	4	4.5	0.188	0.1816	90	0.2207	40.287003	-104.78834	GW	37.22%		
	67.3	5	4.5	0.188	0.3861	90	0.2207	40.287003	-104.78831	GW	0.00%		
	82.75	6	4.5	0.188	0.1857	91	0.2207	40.287002	-104.788157	GW	33.37%		
	124.9	7	4.5	0.188	0.2018	91	0.2207	40.287001	-104.788101	GW	18.15%		

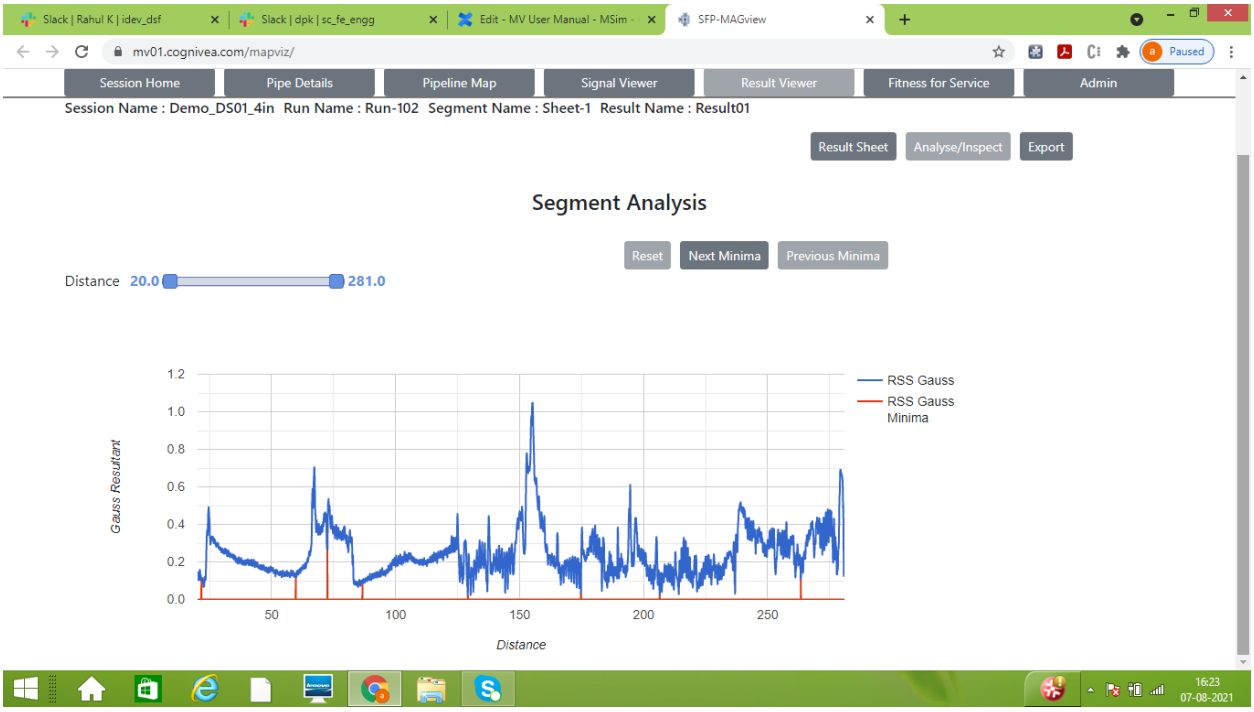
The columns are populated as below

- For each pair of rows, the following fields are analyzed to check if they have any change from one row to the other
    - OD and NWT for any change

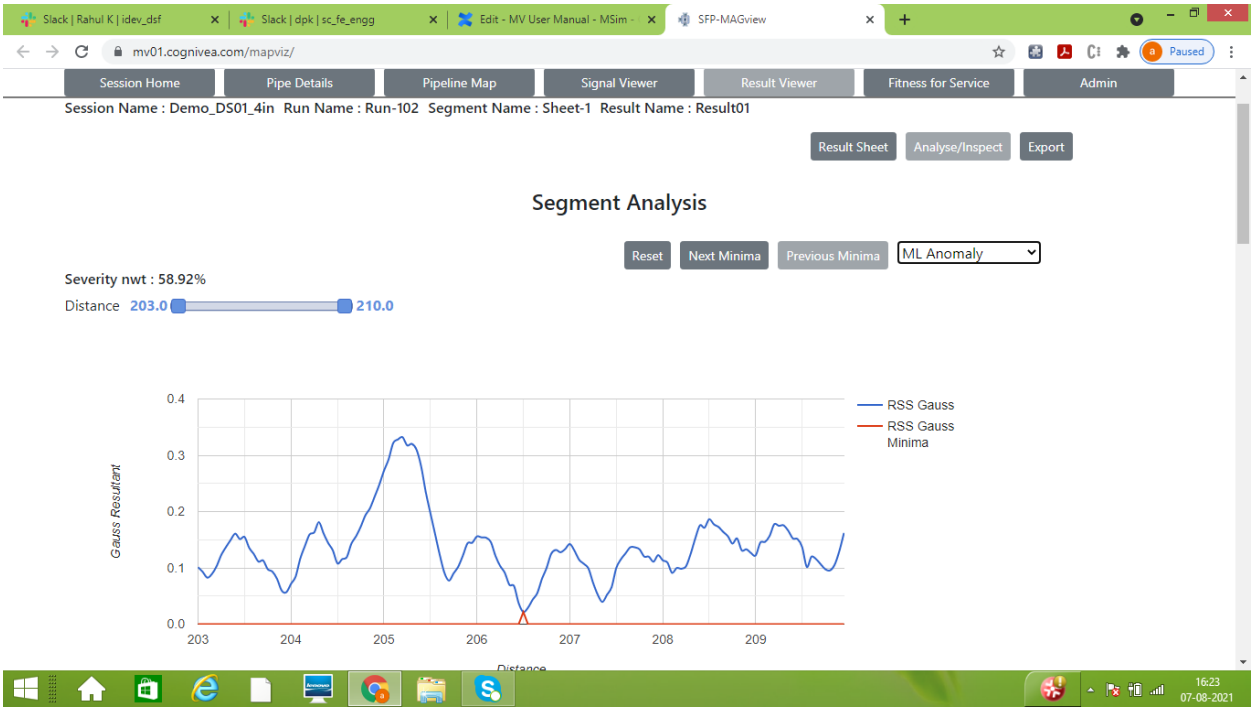
    - Segment Magnetic Heading, if the change is greater than 10 degrees.
- If there is any change, the ‘End Marker’ is marked as 'Start', denoting a segment boundary.
- If the Segment Magnetic Heading between the two rows changes by more than 10 degrees, the feature column for that entry is marked as a ‘Bend’. Otherwise it is marked as a ‘GW’ (Girth Weld)
- For each segment defined by two 'Start' markers, the Average MH Segment Gauss is computed keeping in mind the suppression of readings within +/- 3.3 feet of each girth weld within this segment.
- Severities are calculated based on user provided calculations for the selected model. If the severity model is greater than the ‘Threshold’ set in the Pipe Details menu, the text color of the severity shall be red, otherwise, it will be green.
- The User may want reassign the Segment markers manually. In this case, the user can select the row where he needs to make a change, then select U-Start or U-End(User Start/End). Then the user can deselect the row to enable the ‘OD & NWT' button. The user can then re-click the ‘OD&NWT’ and 'Calculate’ buttons to recalculate.
- Bends in the result sheet can be computed in multiple ways. All GWs are marked as Bend-G. Where a direction change is computed, that is marked as Bend-P. When the bend is due to a change in OD/NWT parameters, it is marked as Bend-O. When the bend occurs due to both change in direction as well as OD/NWT, then it is labelled as Bend-U

Analyzing the Proposed Defects

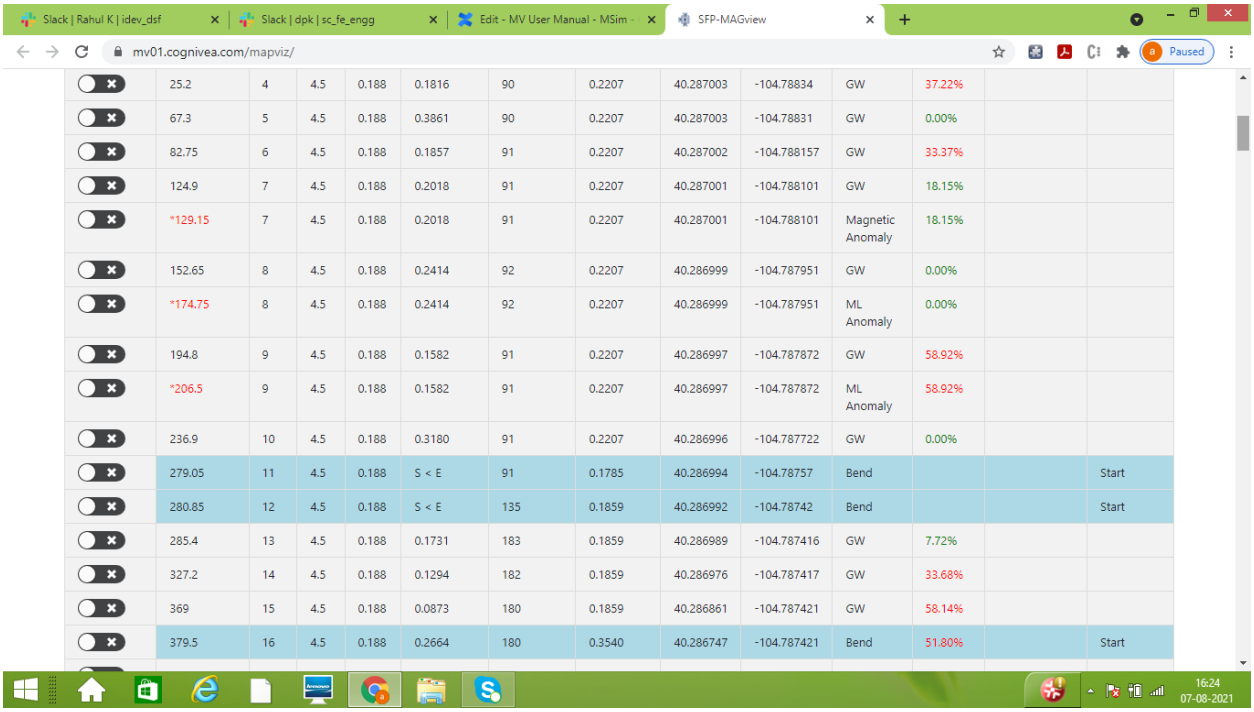
All identified minima may not be defects, so the user will need to mark them as such (ML anomaly or Magnetic Defect). The user can click the row with a ‘Y' marker to select the segment that starts with this row and then click 'Analyze/Inspect’



The user will be presented with a graph containing the measurement readings for that segment along with the locations of the minima. Click ‘Next Minima’ / ‘Previous Minima' to iterate through the ‘Minima’. On clicking these buttons, the user is provided with a zoomed in view of that minima offset as well as the actual readings in the minima’s vicinity. The user can then categorize the minima accordingly.



Zoom settings can be changed using the slider as well. Once all minima are categorized. the user can go back to the Results by clicking the ‘Results Sheet’ button. Minima categorization should now be available in the sheet.

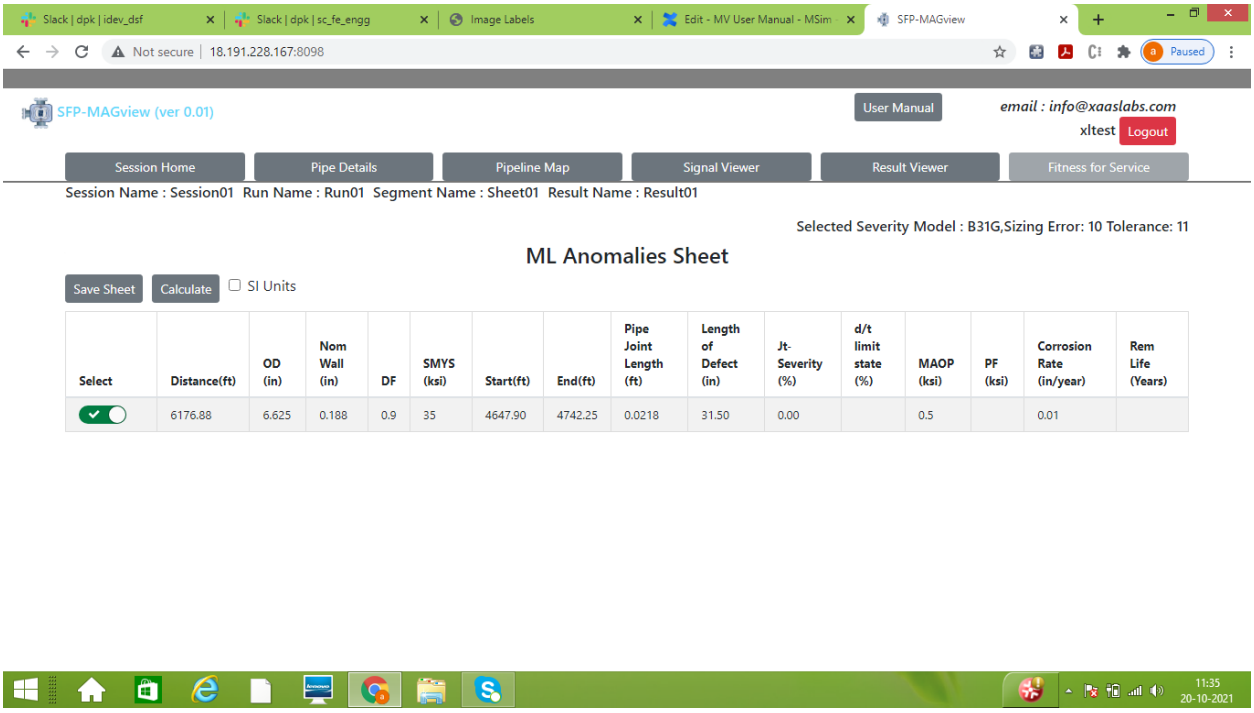


If needed, additional comments can be added in the ‘Reported’ Column'. Once all processing is completed, the Result sheet can be saved for later retrieval or for exporting.

Fitness For Service (FFS)

Once the user has marked all ML Anomalies in the Results and saved the results, Fitness for Service for the pipe joints where ML Anomalies are suspected can be done by clicking the ‘Fitness For Service’ tab. Two calculation models are supported (B31G and Modified B31G), which are selected during Run configuration.

If needed, table values can be viewed in SI units by clicking the appropriate checkbox (SI Units)

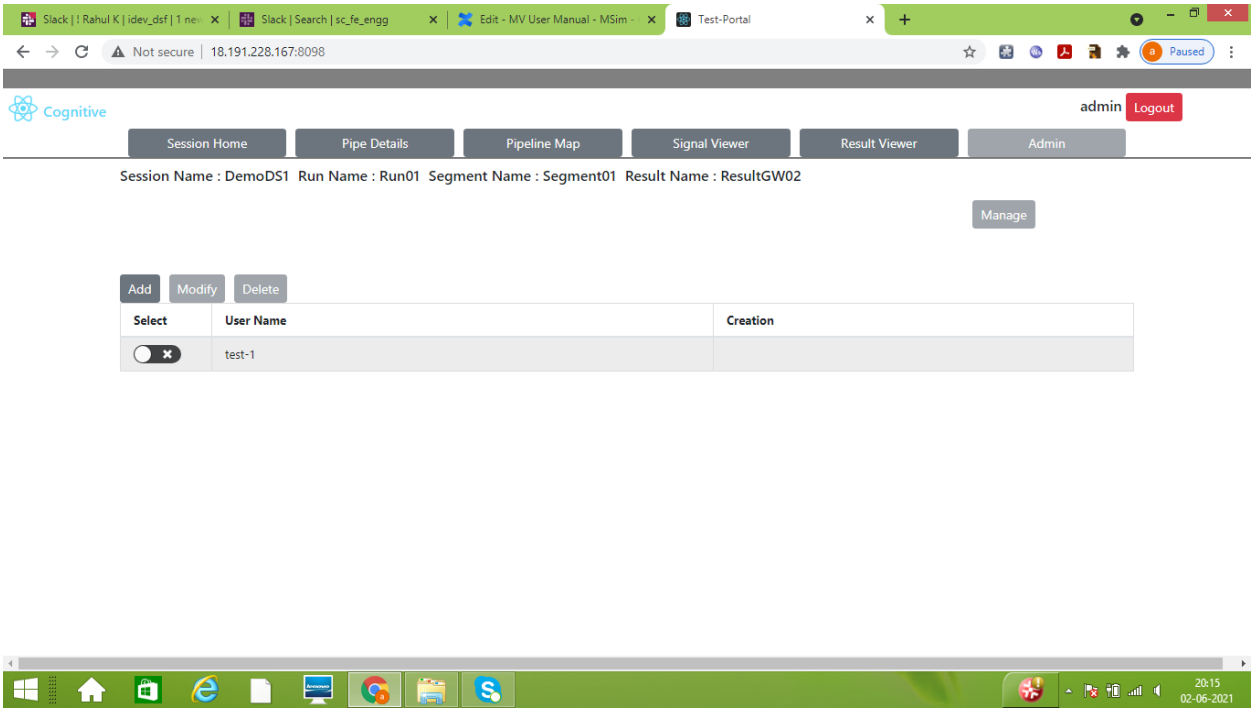


All ML Anomalies are pre-populated in this menu. The user can select any row, enter the length of the defect in millimeters (either measured or inferred value) and click the calculate button to make calculations for

- PFail (PF) - The pressure at which the pipeline is expected to fail. This must be greater than the MAOP.
- Designed D/T - The maximum severity that the pipeline is designed for, for a given length of defect. This must be greater than the Pipe Joint Severity.
- Remaining Useful Life (RUL) - As a derivation of the corrosion rate for that section of pipe at that given location.

Admin Settings

The admin user has access to a menu which can be accessed from the ‘Admin’ Menu option.



Here, the admin user can add or delete user ids and set passwords for them. This can be done using the ‘Add’ , ‘Delete’ buttons in the menu.

Note: Username should start and end with an alphanumeric character but can contain “-, _ or .” in between.

Appendix 1 - Formats of input files

For each run, there are 3 files that need to be uploaded. These are

- Magnetometer sensor readings file - This is a CSV formatted file that contains data in the format

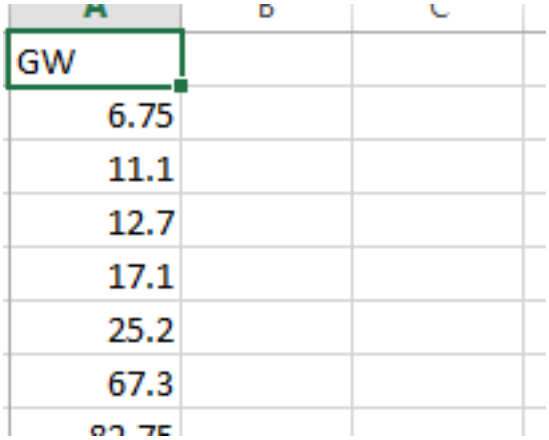
Distance Offset, Magnetometer Reading X, Magnetometer Reading Y, Magnetometer Reading Z

The Distance Offset field is in feet and is incremented in fixed sized steps of 0.05 feet.

For Example, a sample file may look like

A	B	C	D
Distance (ft)	Magnetic Flux X (Gauss)	Magnetic Flux Y (Gauss)	Magnetic Flux Z (Gauss)
0	-0.1113	0.2095	-0.1261
0.05	-0.1306	0.2108	-0.1307
0.1	-0.1173	0.2082	-0.1199
0.15	-0.1181	0.2022	-0.1268
0.2	-0.1236	0.2023	-0.1334
0.25	-0.118	0.2021	-0.1282
0.3	-0.1168	0.2196	-0.1162

- The second file is the Girth Welds Location file. This is also a CSV formatted file and contains a single column that contains the distance offsets of the locations of Girth Welds in the pipeline in feet. A sample file can be as below



GW
6.75
11.1
12.7
17.1
25.2
67.3

- The third file is a KML file that contains the path of the pipeline in the real world. This can be a generated file or one exported from Google Maps / Earth. It may contain various tags denoting place markers however, it must contain **one and only one KML tag of the type <LineString>** which should contain all location coordinates along the pipeline from start to end, taking care to include at a minimum, the coordinates of the points where the pipeline makes a significant bend. This KML is used to automatically compute Segment headings and thus all other parameters related to Segments, so this format is of utmost importance. A sample KML tag could be as below

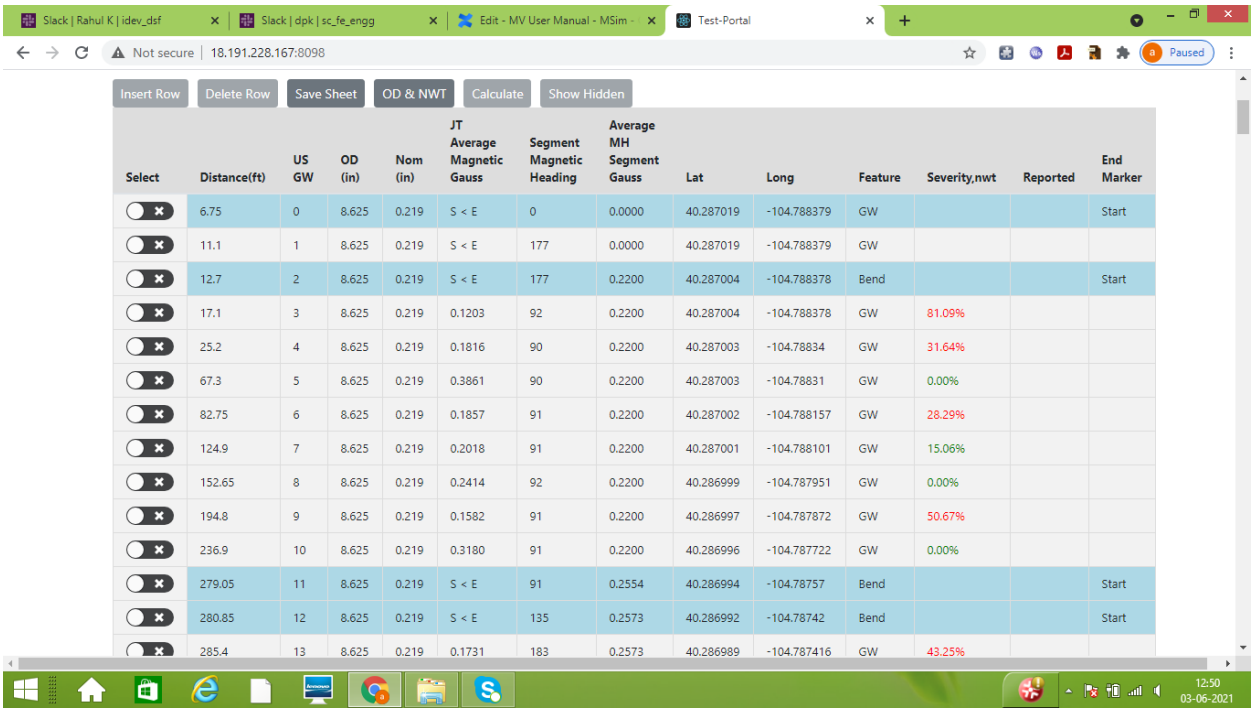
```
<styleUrl>#__managed_style_05B8925F3819FBDE54CC</styleUrl>
<LineString>
<coordinates>79.86024424913867,6.859334342206823,5.823026284392421 79.86022948768701,6.859840658528l6,6.65676667008052 79.86107163235313,6.85
671455582,8.823066473174613 79.86171629267855,6.859994480133643,8.465300378124894 79.86157870021955,6.860780244095743,8.088870690948529 79.86029311751942,6.86070571
734,7.847254084795512 79.86026787222603,6.861217591236628,7.66456875025664 79.86006455948721,6.862658181907622,6.349951336878281 79.85998132776258,6.86319588206797,
4320982361262 79.85977086612712,6.864291005777572,6.685896958533477 79.85947888382924,6.865292620610777,5.549057754402781</coordinates>
</LineString>
```

Here, the first coordinate is the start point and the last coordinate is the end point. Intermediate points can be locations of pipe bends or any other significant points on the pipeline. Altitude values are ignored as of now and can be 0.

Appendix 2 - Understanding The Results Sheet

The Latitude, Longitude and Segment Magnetic Heading fields are filled up by looking up the girth weld offset value in the cumulative distance computed from an uploaded KML file. The nearest coordinates in the KML are used to calculate the heading (bearing) of the pipe joint. The value thus computed is entered into the Segment Magnetic Heading column. This step is done during the ‘Add GW’ phase when the result sheet is first being prepared.

Once the result sheet is brought up and the ‘OD&NWT ’ and ‘Calculate’ options are clicked, most fields in the Results Sheet get filled automatically. Internally, the application first computes Segments based on the changes in Joint Headings and/or OD / NWT parameters. Then the Segment Averages are computed based on the Segment Boundaries (Marked as Blue Rows) and finally, the severity calculations are made based on the selected severity model and threshold.



Select	Distance(ft)	US GW	OD (in)	Nom (in)	JT Average Magnetic Gauss	Segment Magnetic Heading	Average MH Segment Gauss	Lat	Long	Feature	Severity,nwt	Reported	End Marker
	6.75	0	8.625	0.219	S < E	0	0.0000	40.287019	-104.788379	GW			Start
	11.1	1	8.625	0.219	S < E	177	0.0000	40.287019	-104.788379	GW			
	12.7	2	8.625	0.219	S < E	177	0.2200	40.287004	-104.788378	Bend			Start
	17.1	3	8.625	0.219	0.1203	92	0.2200	40.287004	-104.788378	GW	81.09%		
	25.2	4	8.625	0.219	0.1816	90	0.2200	40.287003	-104.78834	GW	31.64%		
	67.3	5	8.625	0.219	0.3861	90	0.2200	40.287003	-104.78831	GW	0.00%		
	82.75	6	8.625	0.219	0.1857	91	0.2200	40.287002	-104.788157	GW	28.29%		
	124.9	7	8.625	0.219	0.2018	91	0.2200	40.287001	-104.788101	GW	15.06%		
	152.65	8	8.625	0.219	0.2414	92	0.2200	40.286999	-104.787951	GW	0.00%		
	194.8	9	8.625	0.219	0.1582	91	0.2200	40.286997	-104.787872	GW	50.67%		
	236.9	10	8.625	0.219	0.3180	91	0.2200	40.286996	-104.787722	GW	0.00%		
	279.05	11	8.625	0.219	S < E	91	0.2554	40.286994	-104.78757	Bend			Start
	280.85	12	8.625	0.219	S < E	135	0.2573	40.286992	-104.78742	Bend			Start
	285.4	13	8.625	0.219	0.1731	183	0.2573	40.286989	-104.787416	GW	43.25%		

In the above screenshot, the third row identifies a pipe joint that starts at 12.7 feet, ends at 17.1 feet, and has a magnetic heading 177 degrees. The start of the pipe joint (at 12.7 feet) is closest to coordinate (40.287004,-104.788378). Since the next row (row four, denoting a pipe joint starting at 17.1 feet) has a change in heading, the third row is marked as a ‘Bend’.

It should be noted that, pipe joints and segments start and end at Girth Weld locations (+/- 3.3 feet). The region between blue rows constitutes a segment which starts from the immediately succeeding row of the starting blue row and ends at the ending blue row. So in the above example, the second segment will start at a distance offset of (17.1 + 3.3) feet and end at (280.85 - 3.3) feet. The segment average is calculated over the identified segment rows after removing all values within +/- 3.3 feet of each intermediate girth weld.

Therefore, the ‘Feature’ and ‘End Marker' columns of a row pertain to the end of the pipe joint that starts at offset filled in the 'Distance’ column of the row.

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