GM CONVEYOR HEALTH ASSESSMENT

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EXECUTIVE SUMMARY

OCC Systems completed inspection on portions of the OH P&F conveyor to demonstrate how the Predictive Database Method can be used to identify and develop a prioritized plan for the replacement of conveyor due to critical wear as determined by stress and deflection calculations.

The allowable stress and deflection values of the conveyor track were calculated under load conditions with Carriers spaced on accumulation centers. We examined static, dynamic and impact loading effects to determine the recommendations for replacement based on the amount of wear that is measured on the bottom flange of the free track. The allowable stress was derived by dividing the ultimate yield strength of the steel by a safety factor of 2.5. The 2.5 value for the safety factor was selected to be consistent with the values used in GM Specification CS1 for track and carrier design. The stress calculations indicate the minimum flange width could be as low as 0.1875 inches. However, experience has shown that localized flange buckling and fatigue failures become the determining factors at values below 0.208 inches. Therefore, 0.208 inches was selected as the minimum threshold for flange wear.

The second major factor in determining track replacement recommendations is bending of the bottom flange which is best illustrated by measuring the spread between the toes of the free channels (or track gap). When this gap grows by 0.25 inches, the point loading due to the trolley wheels moves to the toe of the track flange causing the bending stress values to spike dramatically. This condition also results in the free trolley riding at a lower position relative to the bottom of the power track. This causes a reduction in the amount of bite between the free trolley dogs and the chain pusher dogs. This results in carrier runaway conditions at vertical curves, damage to free trolley guide wheels, chain to chain transfer problems, unexplained carrier count errors in storage banks, and carrier pick-up problems in accumulation areas. All of these problems result in safety issues and lost production. So even though replacement of the rail may not appear to be necessary due to the thickness of the flange, it is still recommended due to excessive bending to the flanges as indicated by the toe to toe dimension being out of tolerance.

Two representative areas were chosen to inspect with our findings and recommendations summarized below.

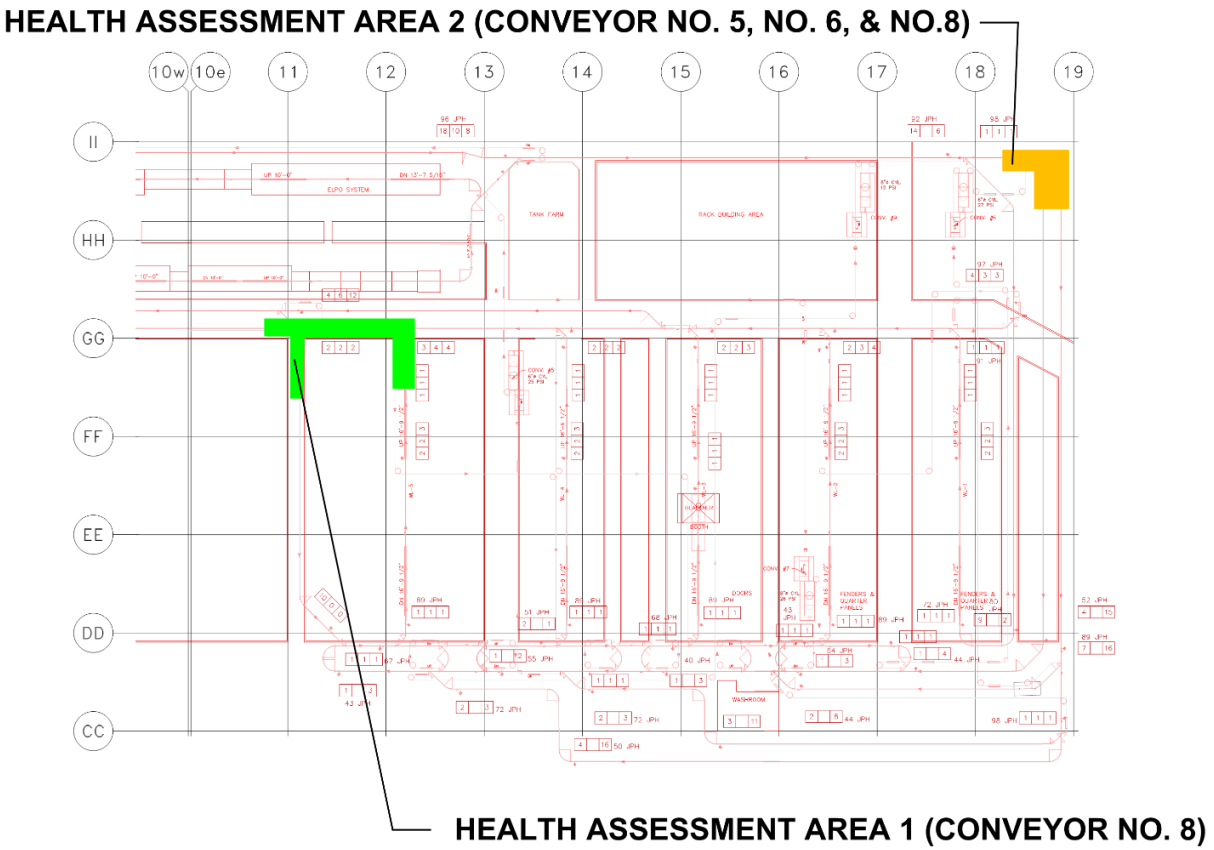
A replacement priority has been assigned based on the following criteria. If flange wear or bending exceeds the recommended values it has been assigned a #1 priority. Track and components approaching the recommended values are assigned a #2 priority and highlighted to be monitored for accelerated wear. Track and components that do not show significant wear are assigned a #3 priority.

All of the track and components in Area 1 showed minor wear and were assigned a #3 priority.

In Area 2, Item #3 was approaching the recommended values and was assigned a #2 priority to be monitored on a regular basis. Items #4 and #5 exceeded the recommended values and were assigned a #1 priority.

The items that are assigned a #1 priority are experiencing stress levels that exceed the recommended design limit, and therefore operating without the typical safety factors considered to be consistent with good industrial practice. While it is impossible to predict when component failures will actually occur, the priority illustrates the order the components are most likely to fail. The replacement timeline is to be determined by GM based on ongoing inspections to monitor track wear, flange bending, available installation windows, and replacement component availability.

GM HEALTH ASSESSMENT OVERALL LAYOUT



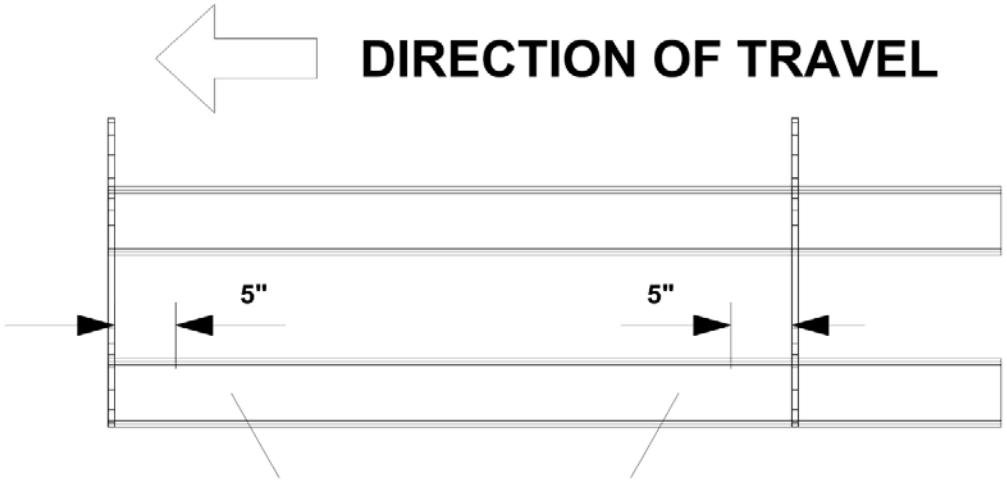
HEALTH ASSESSMENT OVERALL LAYOUT

NO SCALE

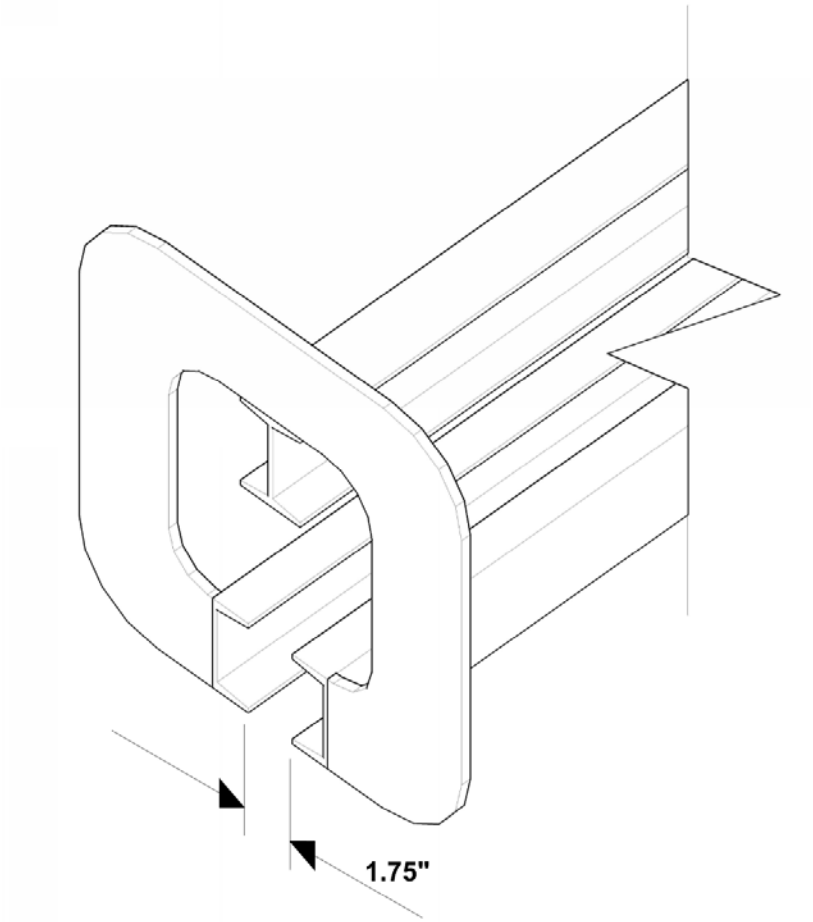
HEALTH ASSESSMENT AREA 1 (CONVEYOR NO. 8)

HEALTH ASSESSMENT AREA 2 (CONVEYOR NO.5, NO. 6, & NO.8)

TRACK GAP



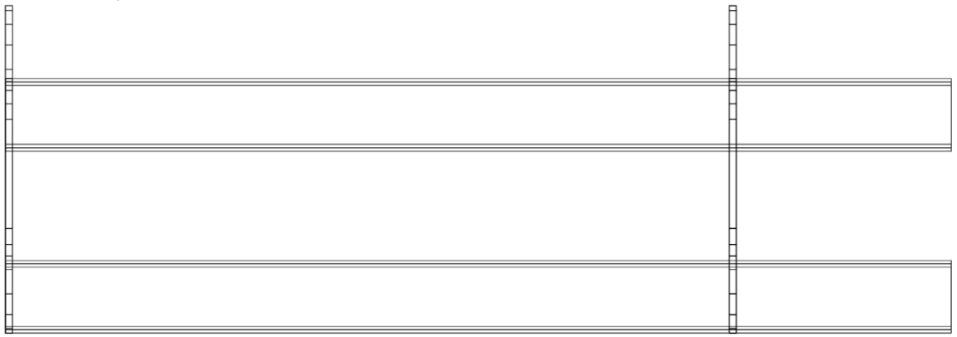
1. EACH TRACK GAP MEASUREMENT IS TAKEN APPROXIMATELY 5" BEFORE OR AFTER A YOKE.
2. EACH MEASUREMENT LOCATION IS ASSIGNED A NUMBER ON AREA 1 & AREA 2 OF THE HEALTH ASSESSMENT MAPS.
3. THE LOCATION NUMBERS ARE CROSS REFERENCED TO EACH AREAS TRACK GAP & TRACK WEAR CHARTS WITHIN THIS REPORT.

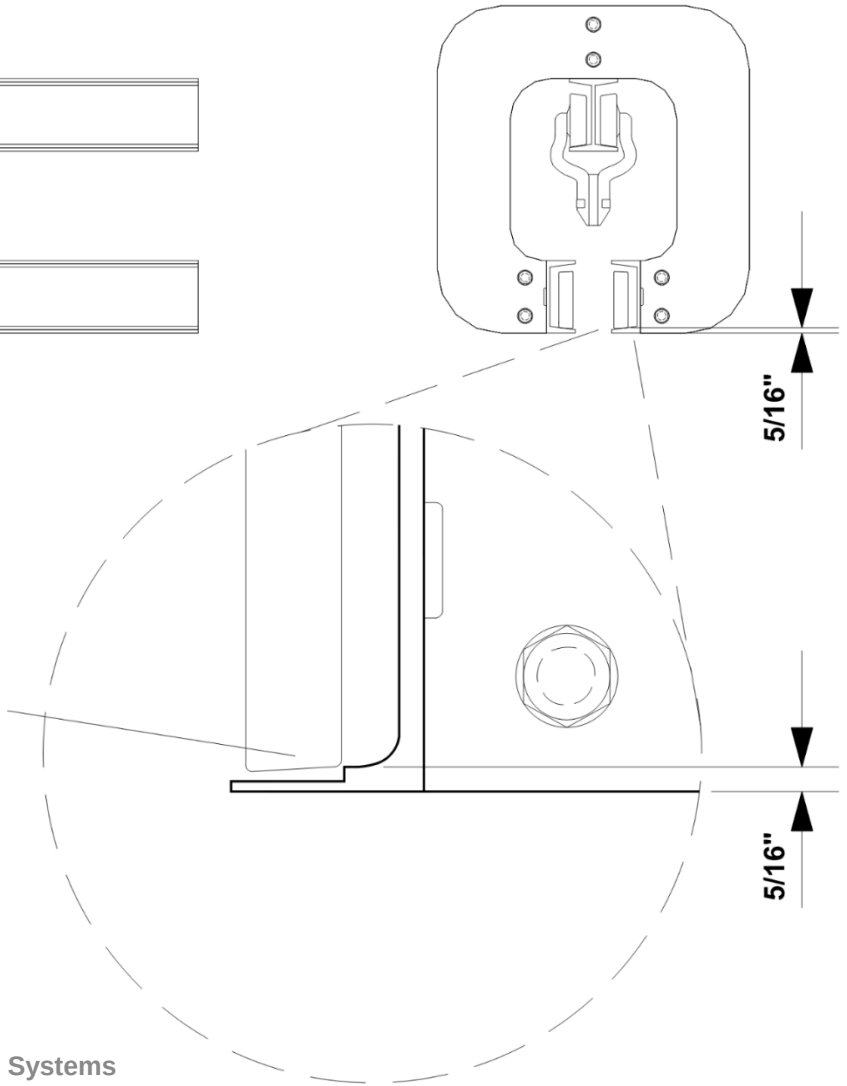


4. THE TARGET MEASUREMENT FOR NEW 4" CONVEYOR IS A TRACK GAP OF 1.75"

FLANGE THICKNESS AND WEAR

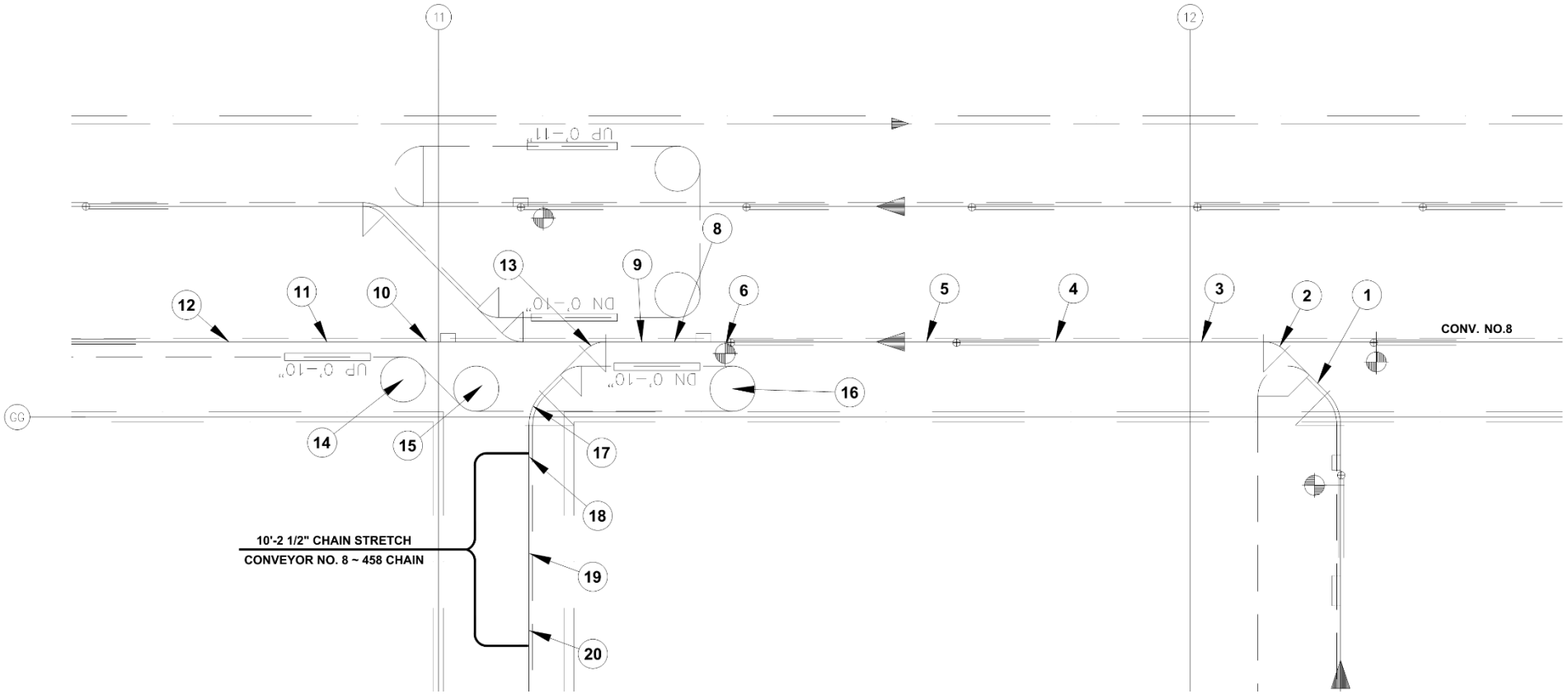
DIRECTION OF TRAVEL





1. TRACK FLANGE THICKNESS IS MEASURED ON BOTH THE LEFT HAND AND RIGHT HAND SIDE OF THE RAIL FOLLOWING THE FLOW OF THE CONVEYOR.
2. THE AREA MEASURED IS AT THE WEAR STEP OF THE TROLLEY WHEEL
3. NEW CHANNEL (C4x5.4) MEASURES 5/16" AT THIS LOCATION.

HEALTH ASSESSMENT AREA 1 POINT MAP



HEALTH ASSESSMENT AREA 1 - CONVEYOR NO.8

NO SCALE

TRACK GAP & TRACK WEAR CHART FOR AREA 1

Track Gap & Track Wear Chart — **Overhead Power & Free Systems**

- Health Assessment Area 1 — **July 2nd, 2018**

Conveyor #8

Track Gap values:

less than 0.125"	Green	Good
0.125" to 0.250"	Yellow	Monitor
0.250" or more	Red	Exceeds limits, replace or repair

% Track Wear values (at wheel tread):

0 - 25%	Green	Good
26 - 32%	Yellow	Monitor
33% or more	Red	Exceeds limits, replace or repair

Within recommended limits, low priority =	3
Approaching recommended limits, medium priority =	2
Exceeds recommended limits, Highest Priority =	1

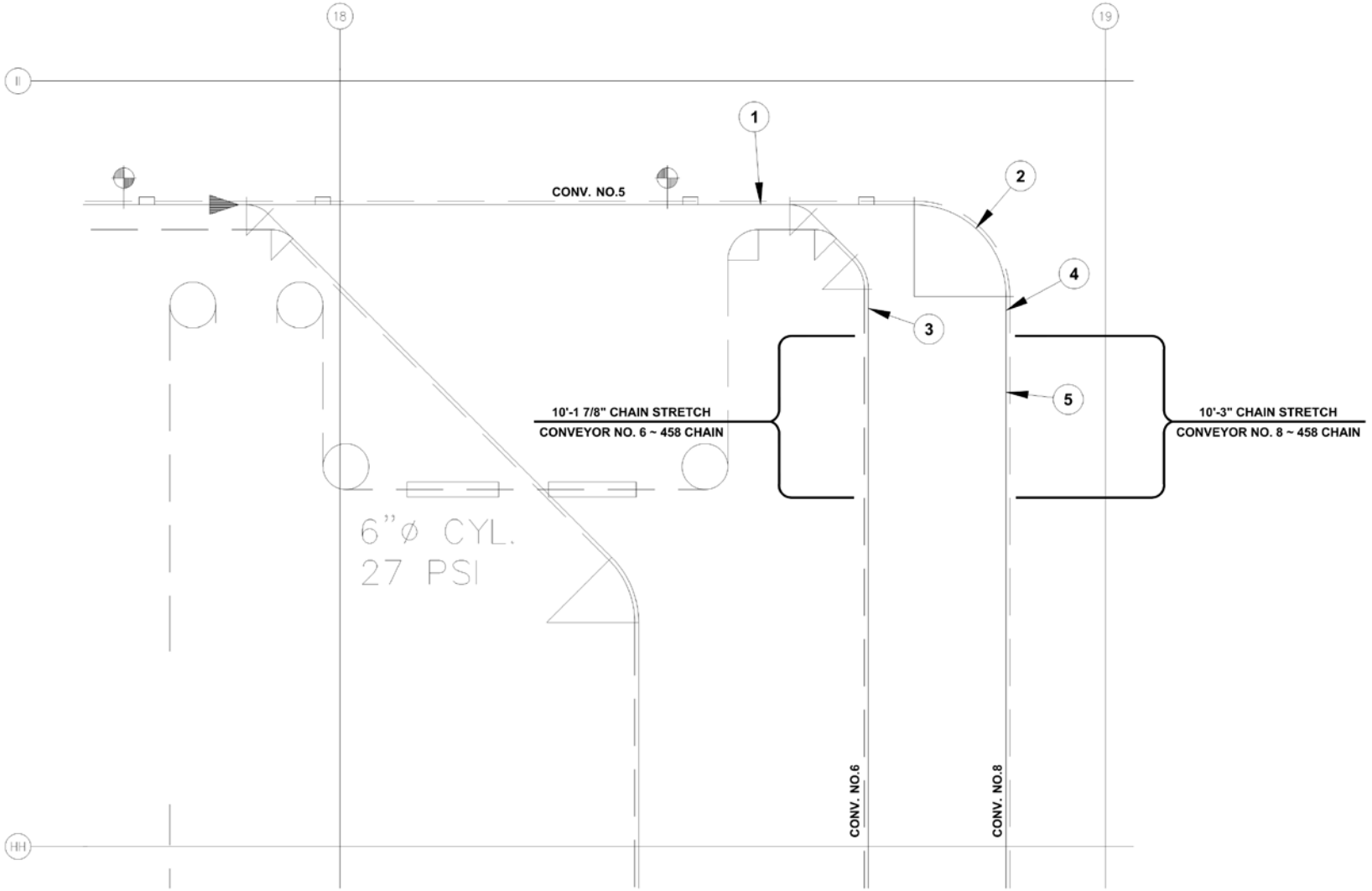
Track Gap				Track Wear								Summary	
Loc #	Track Gap	Extra Gap	Track Status	LH Flange Thick	LH Flange Wear	LH Wear %	LH Track Status	RH Flange Thick	RH Flange Wear	RH Wear %	RH Track Status	Comments	Replacement Priority
1	1.760	0.0100	Good	0.260	0.053	16.96%	Good	0.250	0.063	20.00%	Good		3
2	1.770	0.0200	Good	0.300	0.013	4.16%	Good	0.290	0.023	7.36%	Good	SWITCH - See Conv. Component Chart Below	3
3	1.770	0.0200	Good	0.310	0.003	0.80%	Good	0.290	0.023	7.36%	Good		3
4	1.760	0.0100	Good	0.290	0.023	7.20%	Good	0.310	0.003	0.96%	Good		3
5	1.780	0.0300	Good	0.300	0.013	4.16%	Good	0.300	0.013	4.16%	Good		3
6												STOP - See Conv. Component Chart Below	
7	1.840	0.0900	Good	0.290	0.023	7.36%	Good	0.290	0.023	7.36%	Good		3
8	1.770	0.0200	Good	0.300	0.013	4.16%	Good	0.300	0.013	4.16%	Good		3
9	1.730	-0.0200	Good	0.290	0.023	7.36%	Good	0.290	0.023	7.36%	Good		3
10	1.750	0.0000	Good	0.280	0.033	10.40%	Good	0.280	0.033	10.56%	Good		3
11	1.780	0.0300	Good	0.300	0.013	4.16%	Good	0.300	0.013	4.16%	Good		3
12	1.840	0.0900	Good	0.310	0.003	0.96%	Good	0.320	-0.008	-2.40%	Good		3
13												SWITCH - See Conv. Component Chart Below	
14												TRACTION WHEEL - See Conv. Component Chart Below	
15												TRACTION WHEEL - See Conv. Component Chart Below	
16												TRACTION WHEEL - See Conv. Component Chart Below	
17	1.760	0.0100	Good	0.310	0.003	0.96%	Good	0.300	0.013	4.16%	Good		3
18	1.730	-0.0200	Good	0.290	0.023	7.36%	Good	0.290	0.023	7.36%	Good		3
19	1.700	-0.0500	Good	0.280	0.033	10.56%	Good	0.310	0.003	0.96%	Good		3
20	1.700	-0.0500	Good	0.280	0.033	10.56%	Good	0.300	0.013	4.16%	Good		3

CONVEYOR COMPONENT AND PARTS CHART – AREA 1

Conveyor Component and Parts Chart			Overhead Power & Free Systems
Health Assessment Area 1		Date:	July 2nd, 2018
Conveyor # 8			
		Evaluation	
Location #	Component	Evaluation	Comments
2	**Switches:**		
	Record free track gap at switch if ¼" more than guide wheel diameter.	Good	
	Worn pivot, missing tongue tip supports	Good	
	Clevis loose on rod	Good	
6	**Stops:**		
	Flow controls improperly adjusted	Good	
	Air by-passing regulator	Good	
	Missing anti-backup	Good	
	Bent blade	Good	
13	**Switches:**		
	Record free track gap at switch if ¼" more than guide wheel diameter.	Good	
	Worn pivot, missing tongue tip supports	Good	
	Clevis loose on rod	Good	
14	**Traction Wheel Turns:**		
	Rim wear	Good	
	Rim to wheel welds	Good	
	Chain alignment with rim	Good	
	Loose mounting bolts	Good	
	Poor bearing condition	Good	
	Missing catch frame (overhead)	N/A	
	Missing drip pan	N/A	
15	**Traction Wheel Turns:**		
	Rim wear	Good	
	Rim to wheel welds	Good	
	Chain alignment with rim	Good	
	Loose mounting bolts	Good	
	Poor bearing condition	Good	
	Missing catch frame (overhead)	N/A	
	Missing drip pan	N/A	
16	**Traction Wheel Turns:**		Some chips were present/Burrs
	Rim wear	Good	No significant gouging
	Rim to wheel welds	Good	
	Chain alignment with rim	Good	
	Loose mounting bolts	Good	
	Poor bearing condition	Good	
	Missing catch frame (overhead)	N/A	
	Missing drip pan	N/A	

	CHAIN STRETCH MEASUREMENT:		
CONV. 8	10'-2 1/2"		

HEALTH ASSESSMENT AREA 2 POINT MAP



HEALTH ASSESSMENT AREA 2 - CONVEYOR NO.5, NO.6 & NO.8

NO SCALE

TRACK GAP & TRACK WEAR CHART FOR AREA 2

Track Gap & Track Wear Chart — **Overhead Power & Free Systems**

Health Assessment Area 2 — **July 2nd, 2018**

Conveyor # 5,6 & 8

Track Gap values:

less than 0.125"	Green	Good
0.125" to 0.250"	Yellow	Monitor
0.250" or more	Red	Exceeds limits, replace or repair

% Track Wear values (at wheel tread):

0 - 25%	Green	Good
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Track Gap				Track Wear								Summary	
Loc #	Track Gap	Extra Gap	Track Status	LH Flange Thick	LH Flange Wear	LH Wear %	LH Track Status	RH Flange Thick	RH Flange Wear	RH Wear %	RH Track Status	Comments	Replacement Priority
1	1.760	0.0100	Good	0.290	0.023	7.200%	Good	0.270	0.043	13.60%	Good		3
2	1.700	0.0500	Good	0.320	-0.008	-2.400%	Good	0.290	0.023	7.36%	Good	Twist in Rolled Track Component	3
3	1.990	0.2400	Monitor	0.300	0.015	4.800%	Good	0.300	0.015	4.80%	Good		2
4	2.000	0.2500	Excessive	0.300	0.015	4.800%	Good	0.340	-0.028	-8.80%	Good	Twist in Rolled Track Component	1
5	2.040	0.2590	Excessive	0.300	0.015	4.800%	Good	0.200	0.113	36.00%	Excessive		1

CHAIN STRETCH MEASUREMENT:

CONV- 6	10'-1 7/8"
CONV. 8	10'-3"

CONVEYOR CHAIN GROWTH CHART FOR AREA 1 & AREA 2

Conveyor 458 Chain Growth Chart — **Overhead Power & Free Systems**

Paint Shop — **Date: 7/2/2018**

Percent Chain Life Used:	Track Status:		
0 - 50 %	Green - Good	Within recommended limits, low priority =	3
51 - 90%	Yellow - Monitor	Approaching recommended limits, medium priority =	2
90% or over	Red - Exceeds chain life, replace	Exceeds recommended limits, Highest Priority =	1

Conveyor Number	Chain Size	10'-0" Lg. Average Strand Measurement	Percent Chain Growth	% Chain Life Used	Track Status	Comments	Replacement Priority
8	X-458	122.5000	1.24%	37.50%		AREA 1 - Good	3
6	X-458	121.8750	0.72%	21.88%		AREA 2 - Good	3
8	X-458	123.0000	1.65%	50.00%		AREA 2 - Good but on the max threshhold. Monitor	3
New Chain			121			A 10'-0" strand of new chain measures 10'-1" at install.	
Max Allowable Wear		=	3.3%	4.0		When a 10'-0" strand of chain measures 10'-5", replacement is recommended.	