Helix TECHNOLOGIES

CONVEYOR DESIGN REVIEW

Prepared for

ABC MINING

Mine Operations

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26/02/2007

CONVEYOR NUMBER CV202

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1   **INTRODUCTION**

A design review of Conveyor number CV202 has been undertaken by Helix Technologies Pty Ltd for ABC Mining. A model of the conveyor was built in the Helix delta-T software program and then a series of Dynamic Analysis calculations were performed.

Detailed design reports obtained from the Helix delta-T software have been attached in the appendices. This report summarises the detailed reports and highlights certain observations made during the review process.

2   **OBJECTIVE**

The objective of this report is to review the design of the conveyor with an emphasis on the starting of the conveyor and the load on the drives.

3   **BASIC DESCRIPTION OF CONVEYOR**

3.1   **Basic Dimensions and Capacity**

The conveyor is 292m long and has a lift of 32.94m. Design capacity is 9400 tph of iron ore. There are concave and convex vertical curves in the conveyor.

3.2   **Drives**

The conveyor is fitted with a single Drive pulley which has two drives, one on each end of the shaft, each with a 630kW drive.

3.3   **Takeup**

A vertical gravity takeup is fitted after the head drive on the return belt run. Takeup tension is maintained at 131kN.
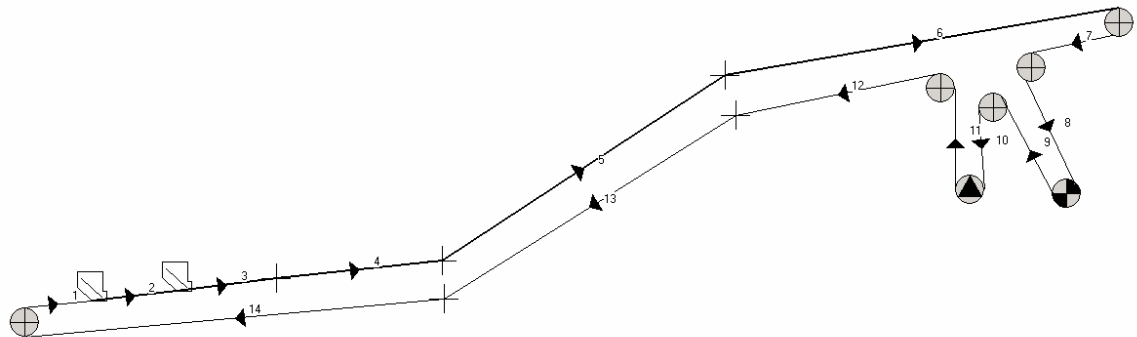
3.4   **Conveyor Belt**

Belt width is 1800mm. Conveyor Belt is a Steel belt ST1800 with 22x7 covers. Belt speed is 4.3m/s.
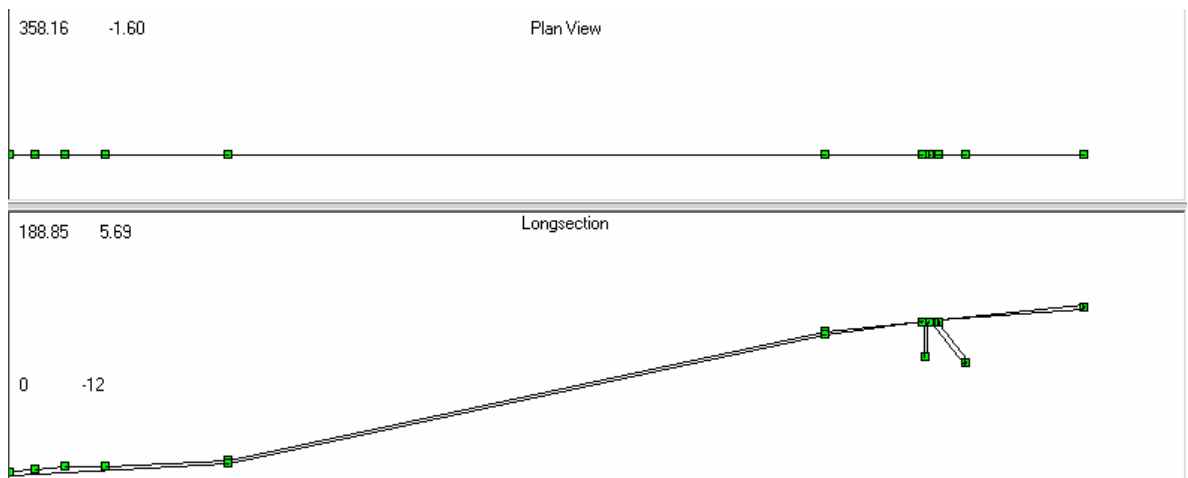
3.5   **Idlers**

Carry idlers are 3 roll, 35 degree trough, 152mm roll diameter spaced at 1.5m. Return idlers are 1 roll flat return, 152 mm roll diameter idlers spaced at 3.0 m.

3.6   **Schematic of Conveyor**

## 3.7   **Conveyor Plan and Longsection**

The sketches above use different horizontal and vertical scales.

4   GENERAL DESIGN OBSERVATIONS - STATIC ANALYSIS

4.1   Belt Rating and Belt Tensions

The installed belt is a ST1800 belt. The allowable operating tension rating for this belt is 253kN per m. Running tensions have been calculated as 235kN/m and the 'Static Analysis' Starting or Braking Tensions are 260.5kN/m. The normal allowable tension rise during starting is 150% of belt rating so this conveyor will be operating within the manufacturers rating.
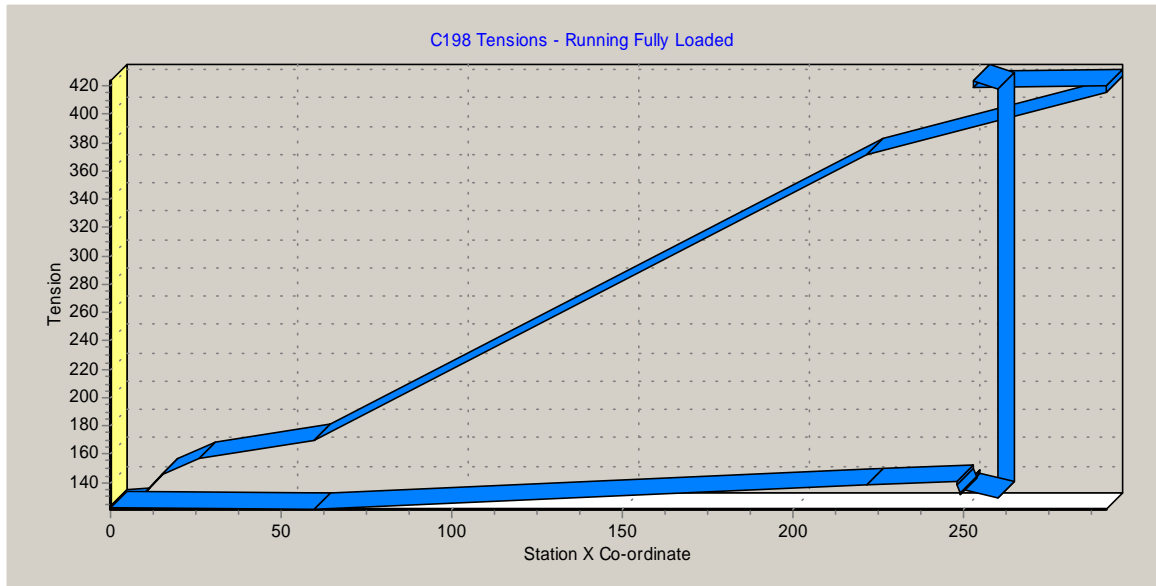
4.1.1   Running Belt Tensions
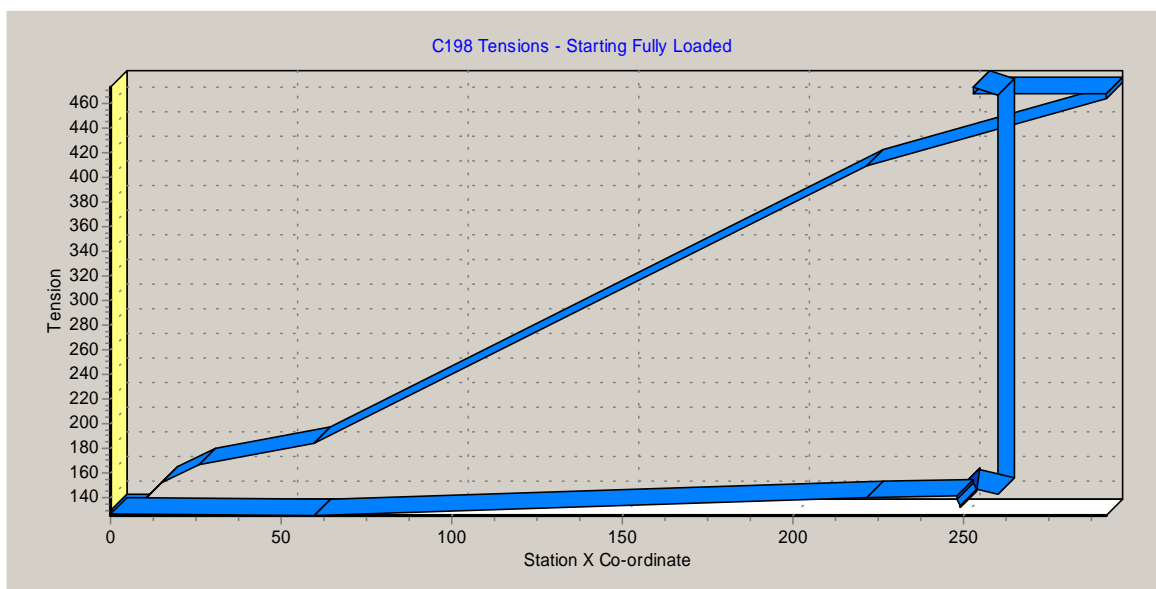
4.1.2   Starting Belt Tensions

4.2 Belt Speed and Capacity

Design belt speed is 4.3m/s and at this speed the belt will be operating at 90% of normal maximum capacity based on a bulk density of 1900kg/m and a material surcharge angle 15 degrees. Belt to Material Edge distance has been calculated to be 127mm.

4.3 Conveyor Friction Factor

The conveyor friction factor on the carry side of the conveyor has been calculated based on the belt sag. The 1.5m idler spacing has increased the friction factor to 0.0224 over one section of the conveyor.

4.4 Demand and Installed Power

The calculated belt power (Using the ISO 5048 calculation method) at the drive pulley is 170kW Running empty and 1259kW running fully loaded. This translates to an estimated fully loaded absorbed power of 1325kW using a drive efficiency of 95%.

The conveyor has two 630kW 6 pole motor drives fitted with ABC GB5020 gearboxes. The motors are Toshiba 6600Volt wound Rotor slip ring type with resistance starting. This 1260kW installed power means that the conveyor will be operating above installed power at 9400tph.

4.5 Takeup and Drive Traction

The minimum takeup tension required for starting and running is 126kN and the design value used is 131kN to allow a safety margin. This traction has been calculated based on drive wrap angles of 180 degrees. Refer to Takeup and Drive Traction Report for details.

4.6 Carry and Return Idlers

Carry idlers are 3 Roll, 152 diameter 35 degree Series 55 trough idlers spaced at 1.5m. Return idlers are 1 roll, 152 diameter flat return series 45 spaced at 3m centres. Carry idler bearing life has been calculated at 144,000 hours based on a belt deviation load of 667N and a Dynamic Load factor of 1.26.

Return Idlers appear to have reduced bearing life and excessive shaft deflections. Refer to Idler Report for more details.

4.7 Speed Reducer

A speed reducer with a ratio of 12.21:1 is fitted. Make is ABC GB5020.

4.8 Conveyor Starting

The starting method is detailed in a separate document prepared by others. It results in a typical "Saw Tooth" speed torque curve at the motor shaft with the following characteristics:

C198 Starting
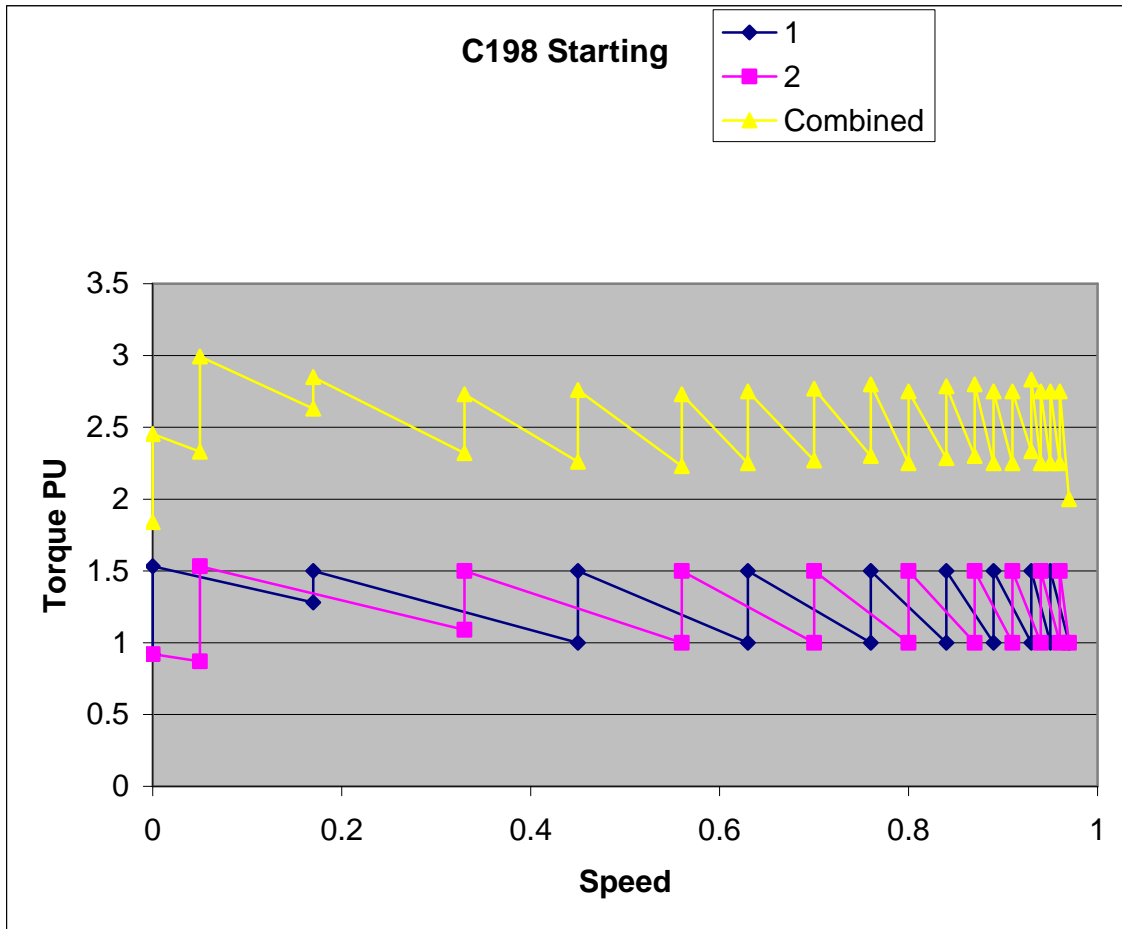
As can be seen from the above curve, the starting torque is controlled between 100 and 150% of motor full load torque. The control system has a fixed time of 5 seconds for the first step on drive 1 and all subsequent steps are controlled as a percentage of Tail pulley velocity.

4.9 **Conveyor Stopping**

The conveyor has a disc brake fitted with a high speed torque rating of 2350Nm. This has been incorporated in the calculations.

4.10 **Vertical Curve Radii**

The conveyor has concave and convex vertical curve. The calculated minimum radii are 364m and 782m respectively

4.11 **Conveyor Pulleys and Shafts**

Conveyor Drive pulley diameters have been installed as 1000mm and 850mm over steel.

5   DYNAMIC ANALSYIS OF CONVEYOR

5.1   Load and starting cases considered

The following cases have been modelled and investigated.

5.1.1   Case 1 - Starting Fully Loaded, single drive pulley, two motors using the combined Torque Speed curve on the pulley. This case is modelled as a single drive pulley.

5.1.2   Case 2 - Starting Fully Loaded, two drive pulleys, two motors using the individual Torque Speed curve on the separate pulleys. This case is modelled to determine if an undue load share is being taken by one of the drives.

5.1.3   Case 3 - Starting Empty, single drive pulley, two motors using the combined Torque Speed curve on the pulley. This case is modelled as a single drive pulley.

5.1.4   Case 4 - Starting Empty, two drive pulleys, two motors using the individual Torque Speed curve on the separate pulleys. This case is modelled to determine if an undue load share is being taken by one of the drives.

5.1.5   Case 5 - Stopping Fully Loaded with brakes applied. Single Drive Pulley.

### 5.2   Case 1 - Starting Fully Loaded

5.2.1   Belt Velocities
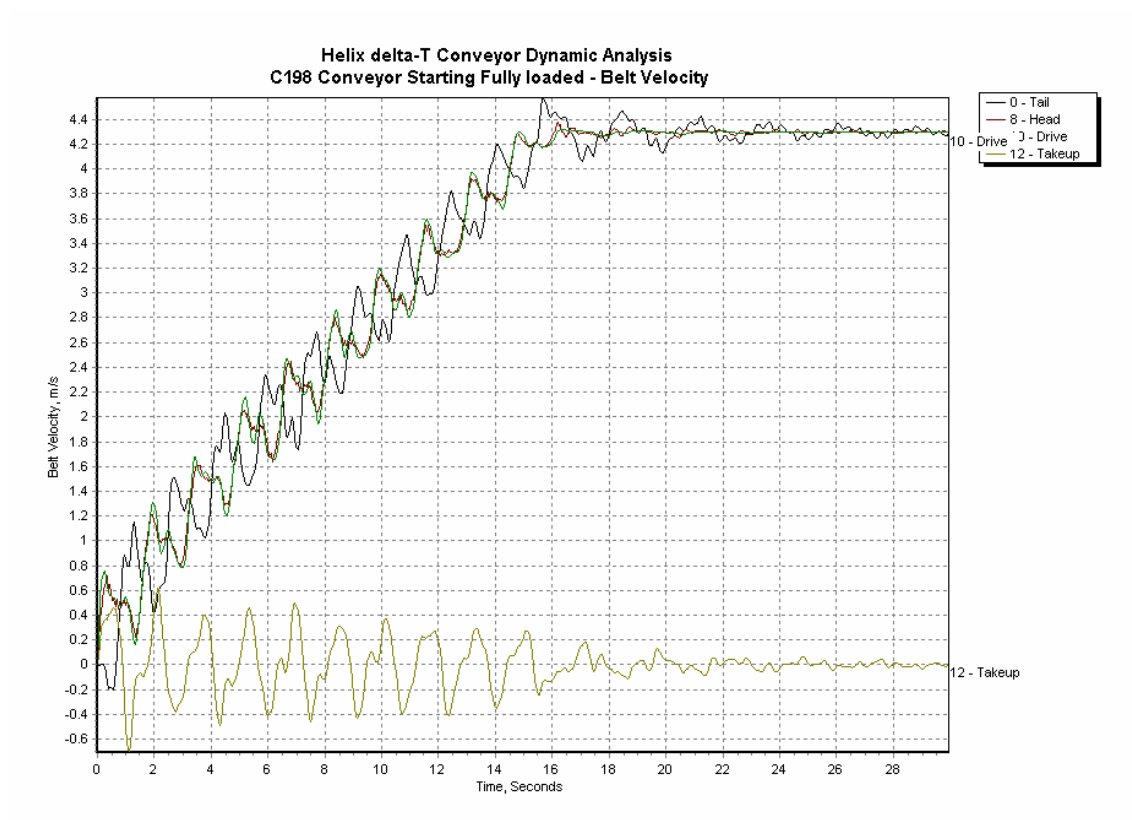
The fully loaded start results in the Drive pulleys reaching full speed after about 16 seconds. The tail pulley starts to move after 5 seconds and accelerates rapidly. The tail pulley speed actually goes well over the design speed and peaks at 5.3m/s 28 seconds after starting. The tail pulley speed will oscillate for a period of time before settling at the design speed.
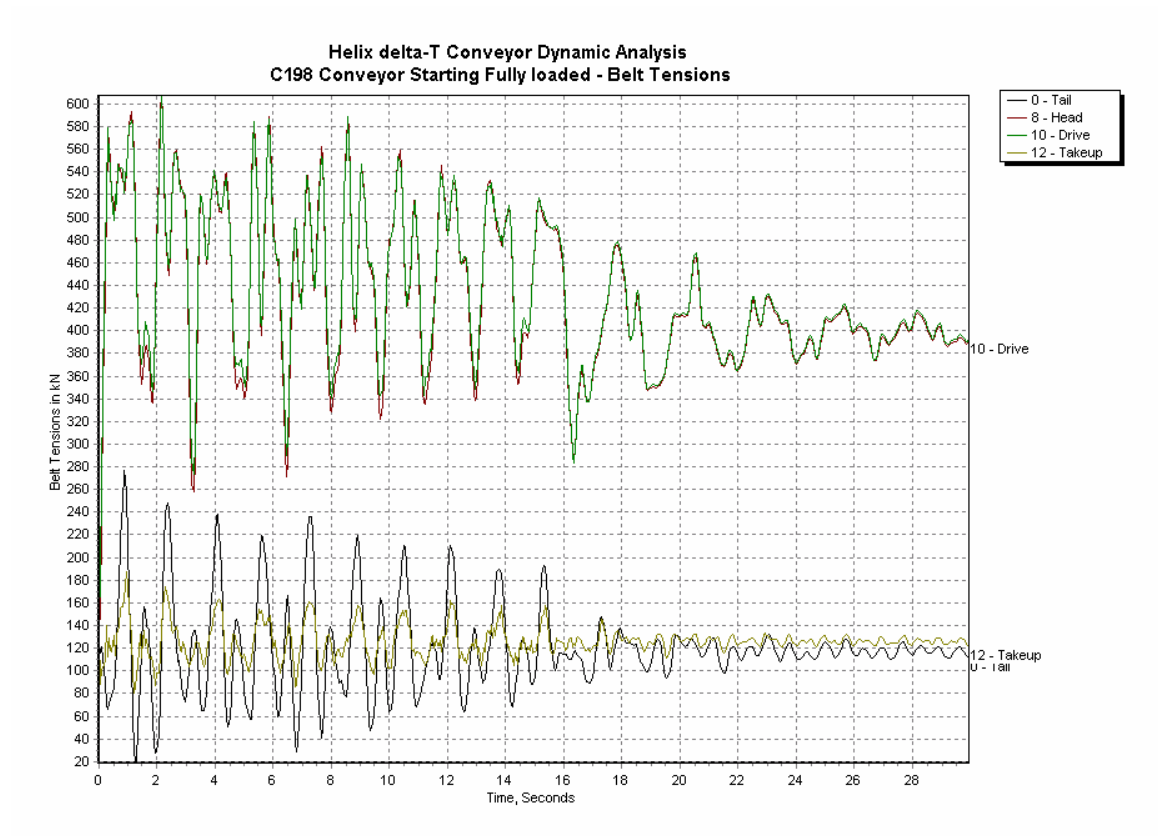
5.2.2   Belt Velocity - Zoomed view 1
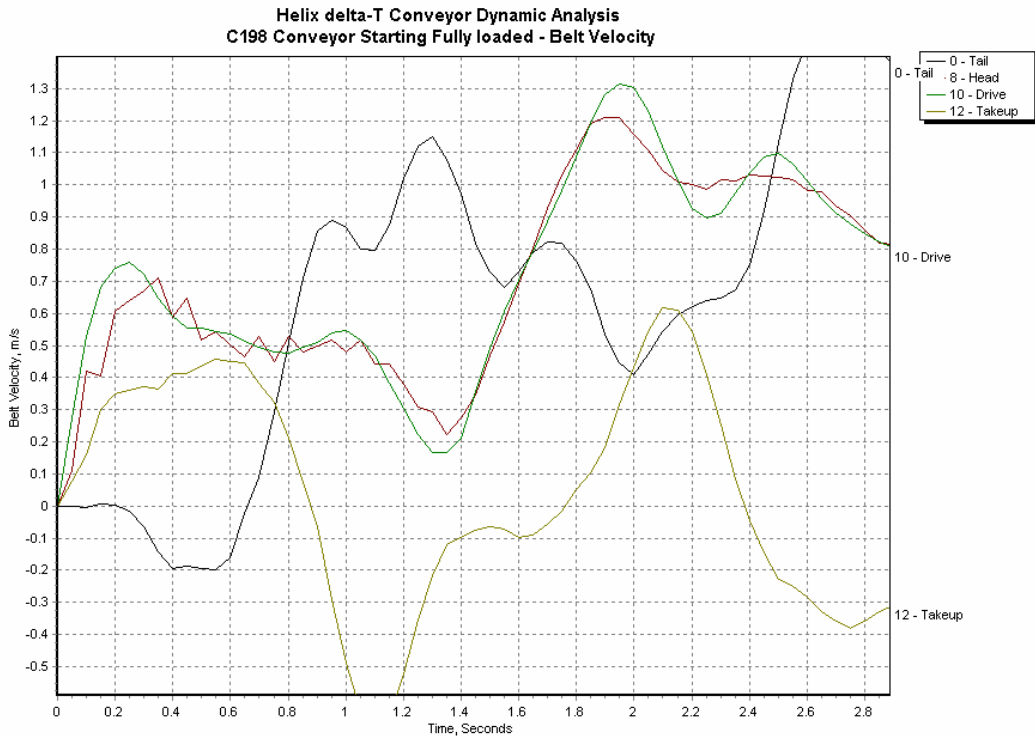
Note Tail pulley starts to accelerate 0.6 seconds after start. It reaches 1.5m/s in less than 3 seconds.

5.2.3   Belt Velocity - Zoomed view 2
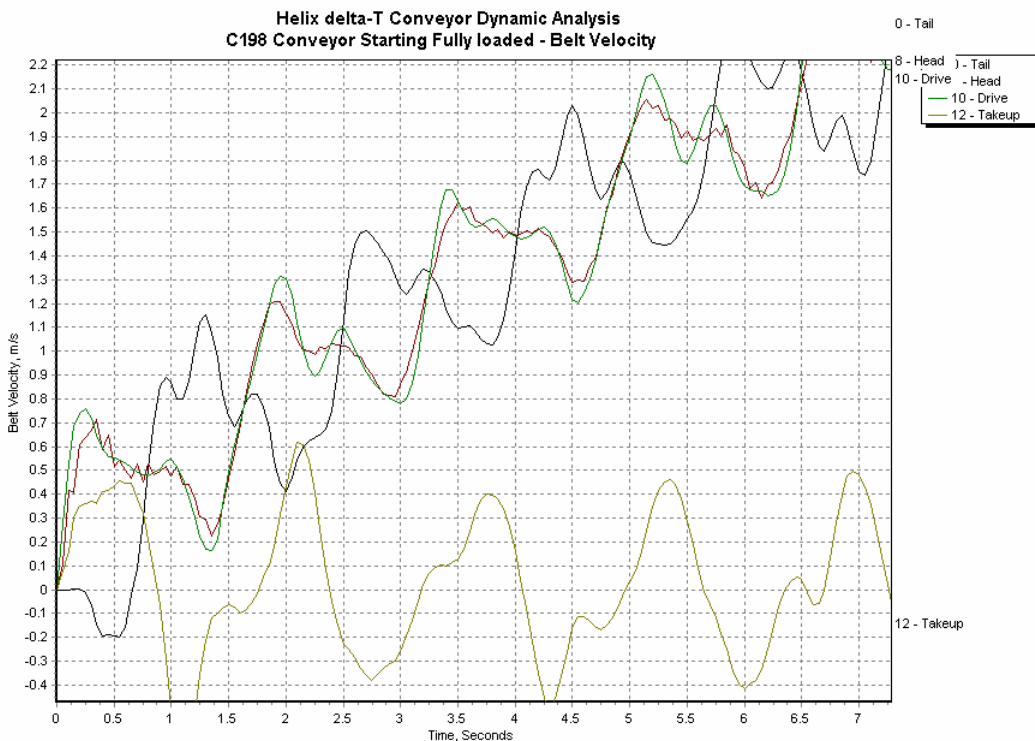
5.2.4   Belt Tensions

Belt tensions peak at 600kN at the drive. This yields a safety factor of 5.4 of belt breaking tension. Note Tension fluctuations over large amplitude.

5.2.5   Gearbox Torque Loading

Torque rating of gearbox is calculated as 941.8kW x 9550 / 81.9 = 109.8kNm. Refer ABC datasheet.

Torque load (peak) from tension graph = 600kN - 131kN = 469kN. Pulley OD is 1024mm.

Therefore torque load on gearbox during starting peaks at 469kN / 2 drives = 234.5kN per drive.

234.5 x 0.512 = 120.06kNm. Calculated service factor is only 0.915 where a minimum of 1.3 is usually desirable.
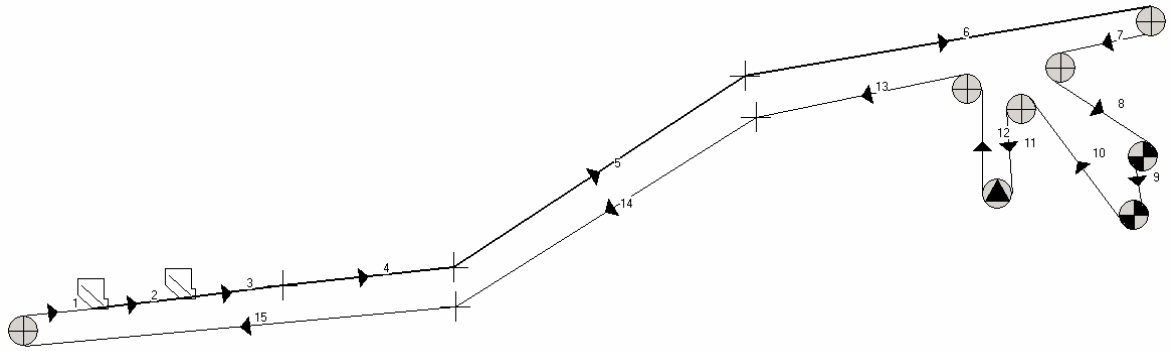
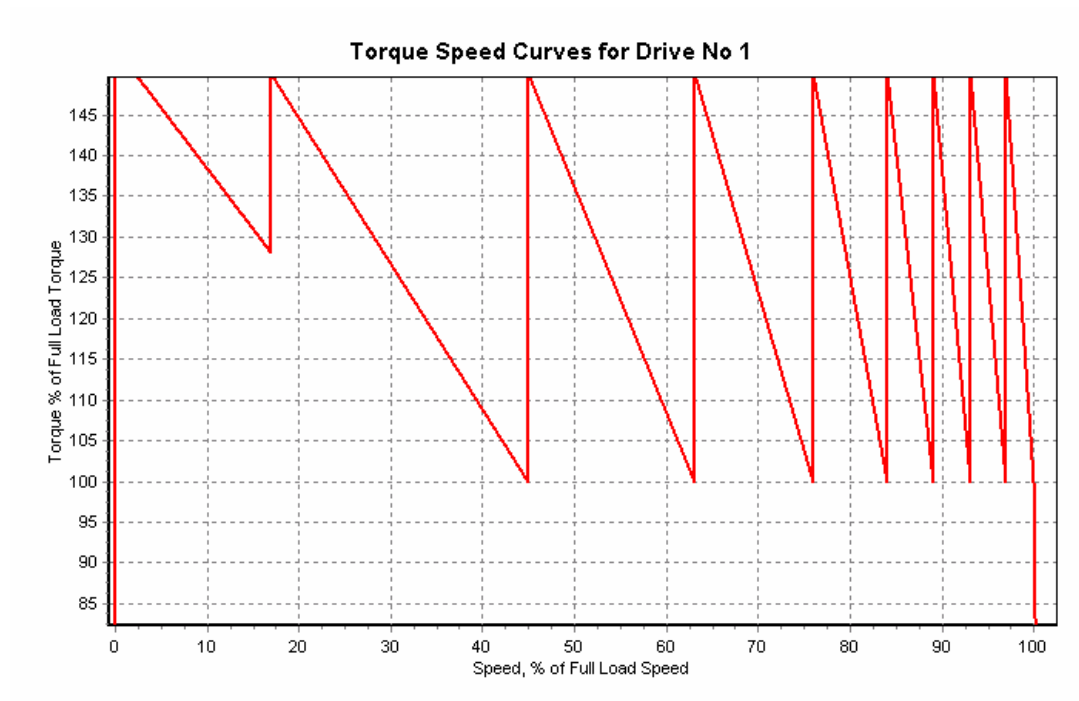### 5.2.6 3D Belt Tensions
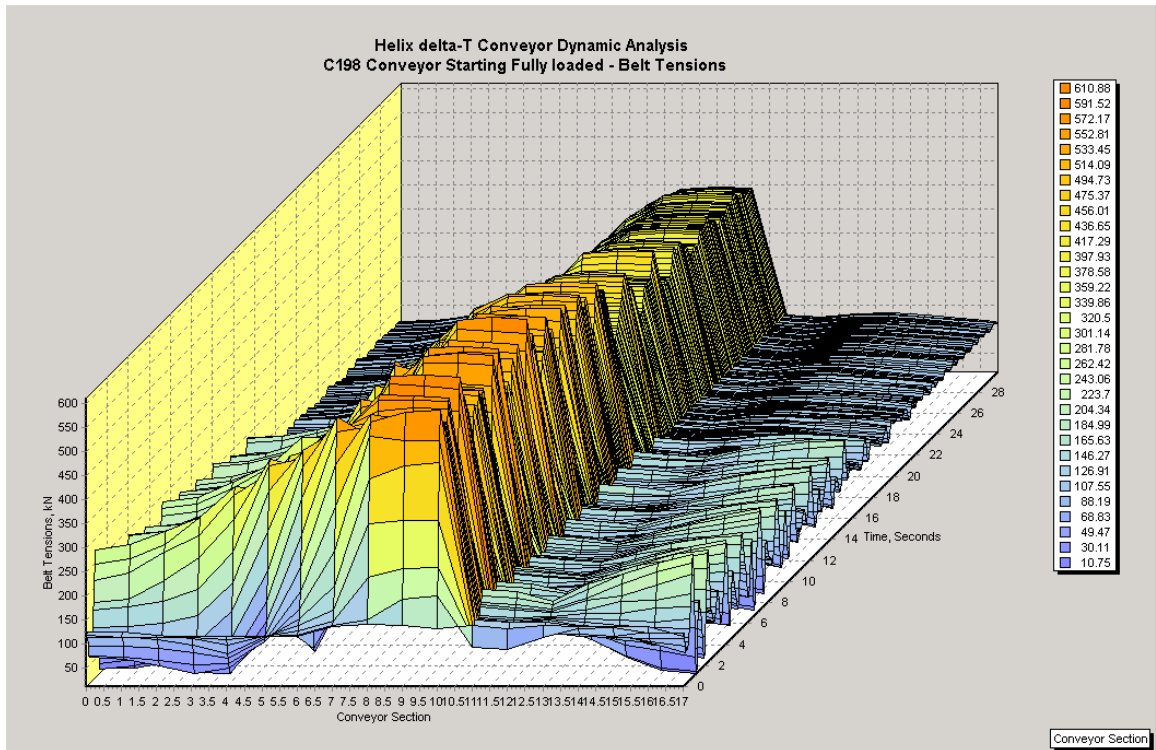
5.2.7 Takeup Travel
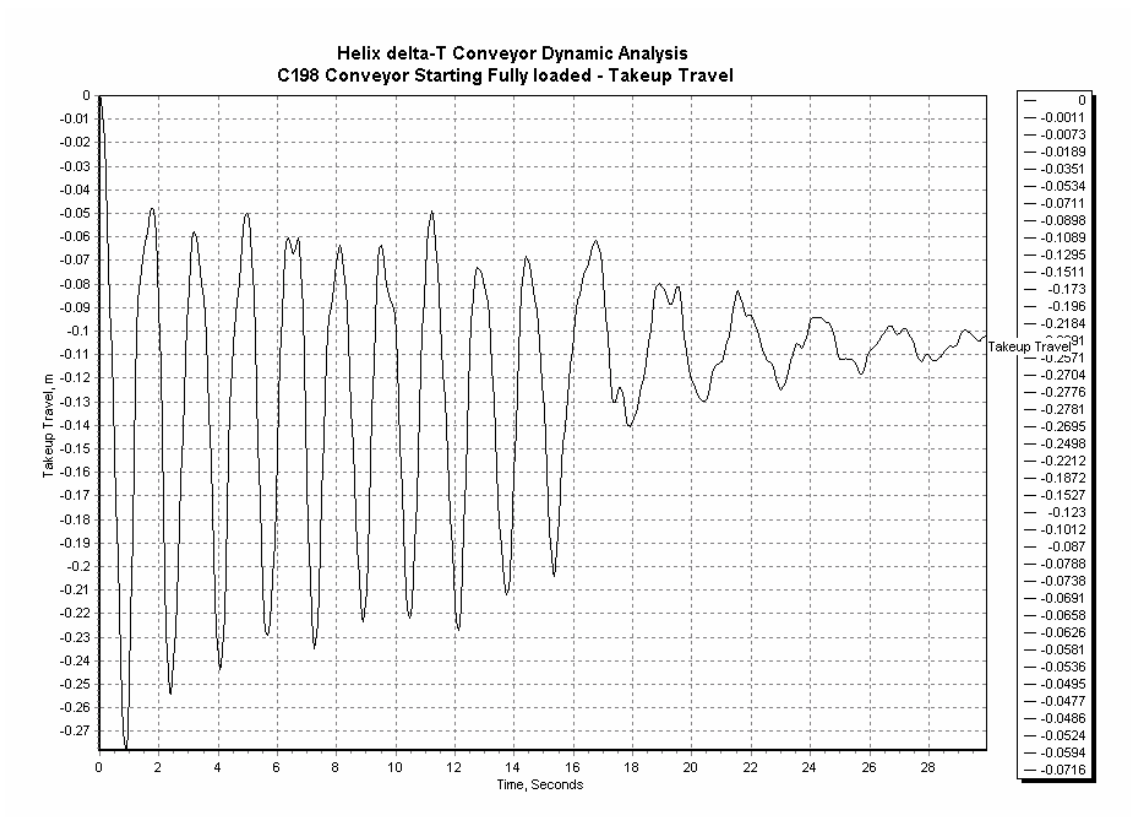
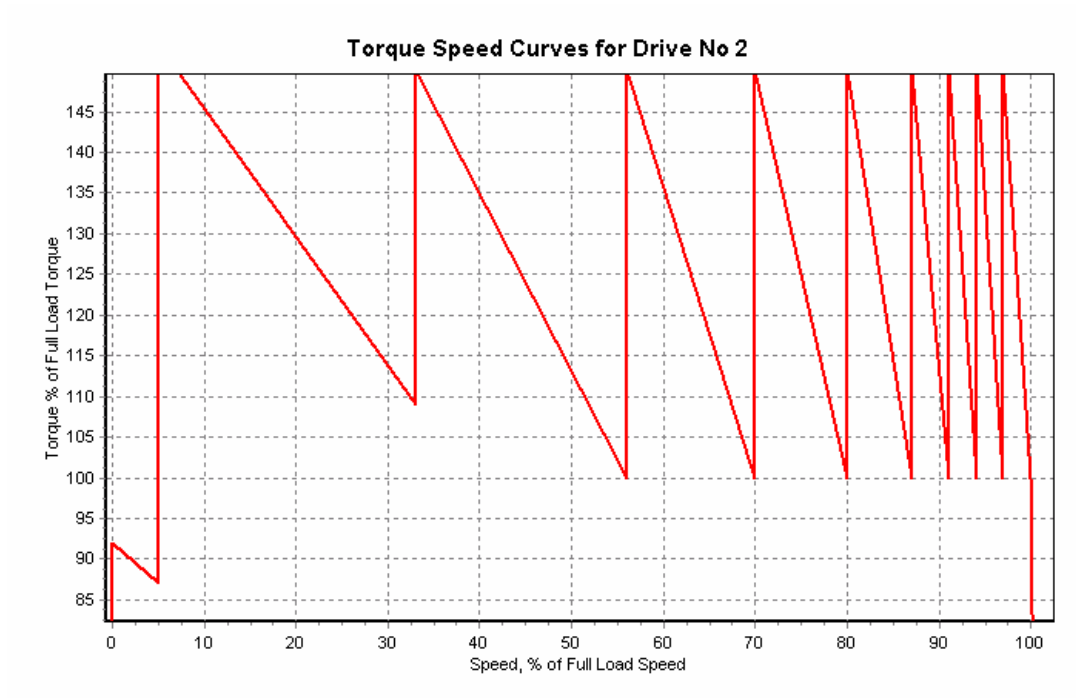### 5.3   **Case 2 - Starting Fully Loaded, two drive pulleys**

A second drive pulley is added into the system so that the drive motors can be modelled separately. Note that Belt tensions are not correct at second drive as only one pulley actually is installed.
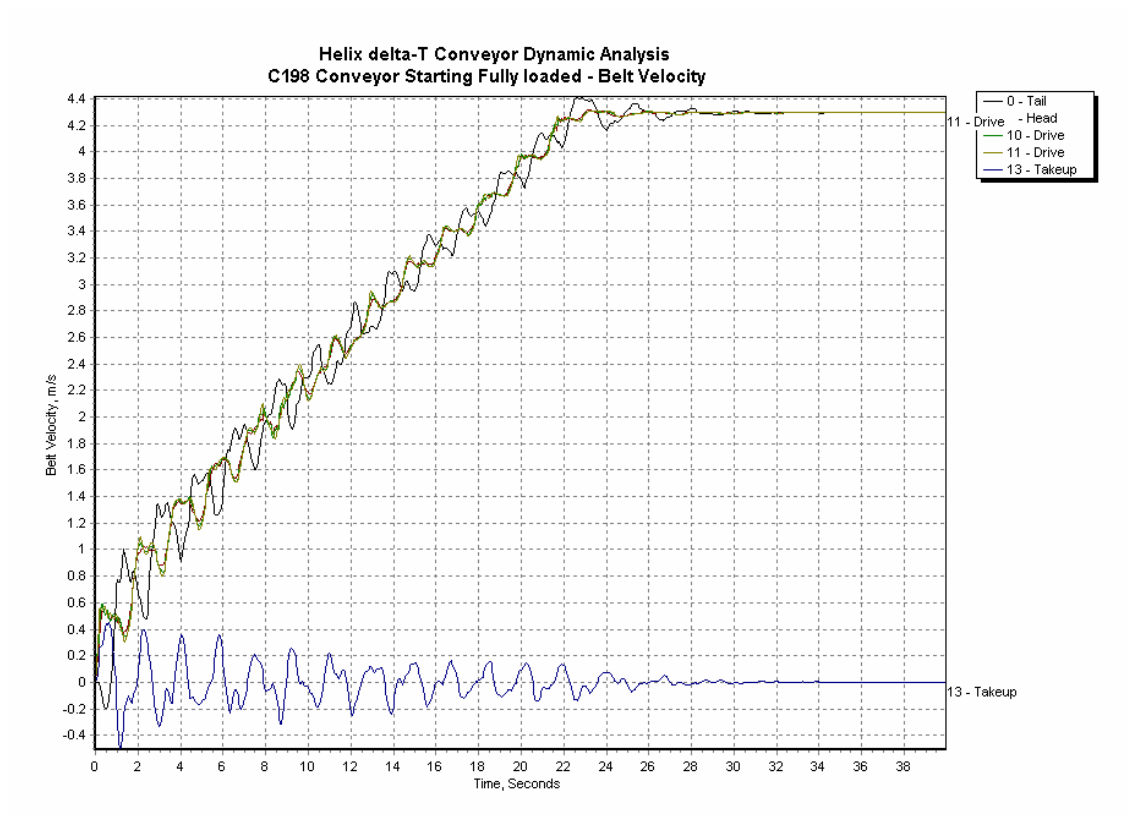

5.3.1   Starting Torque Speed Curve Drive 1

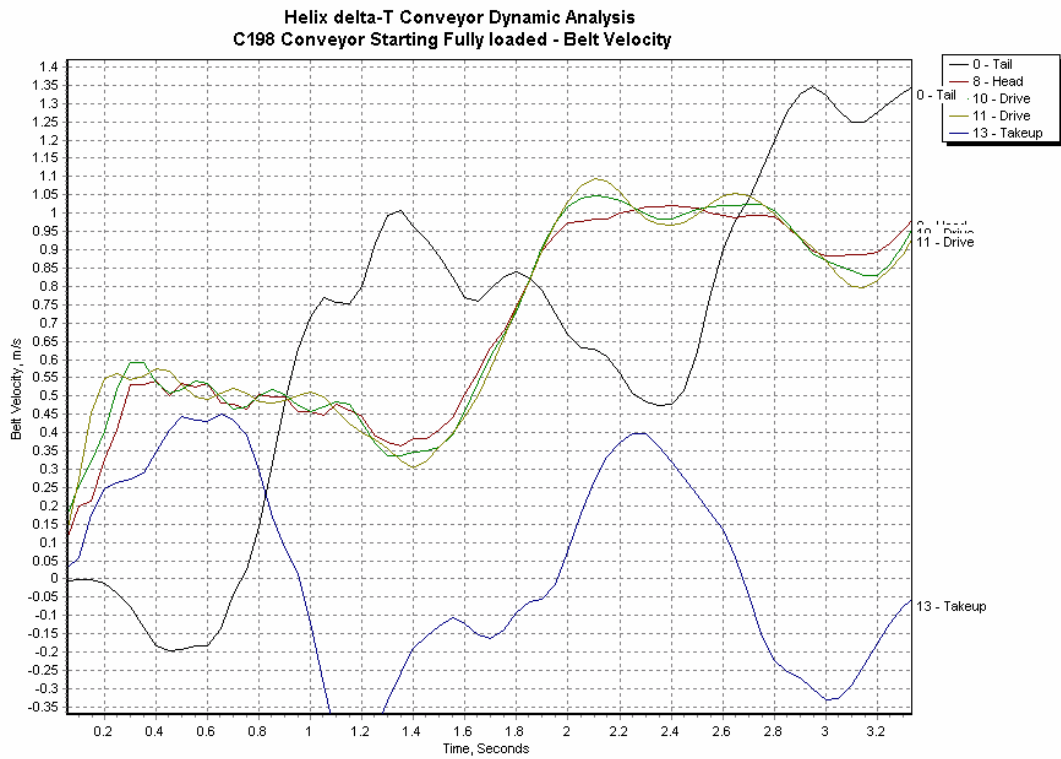#### 5.3.2   Starting Torque Speed Curve Drive 2

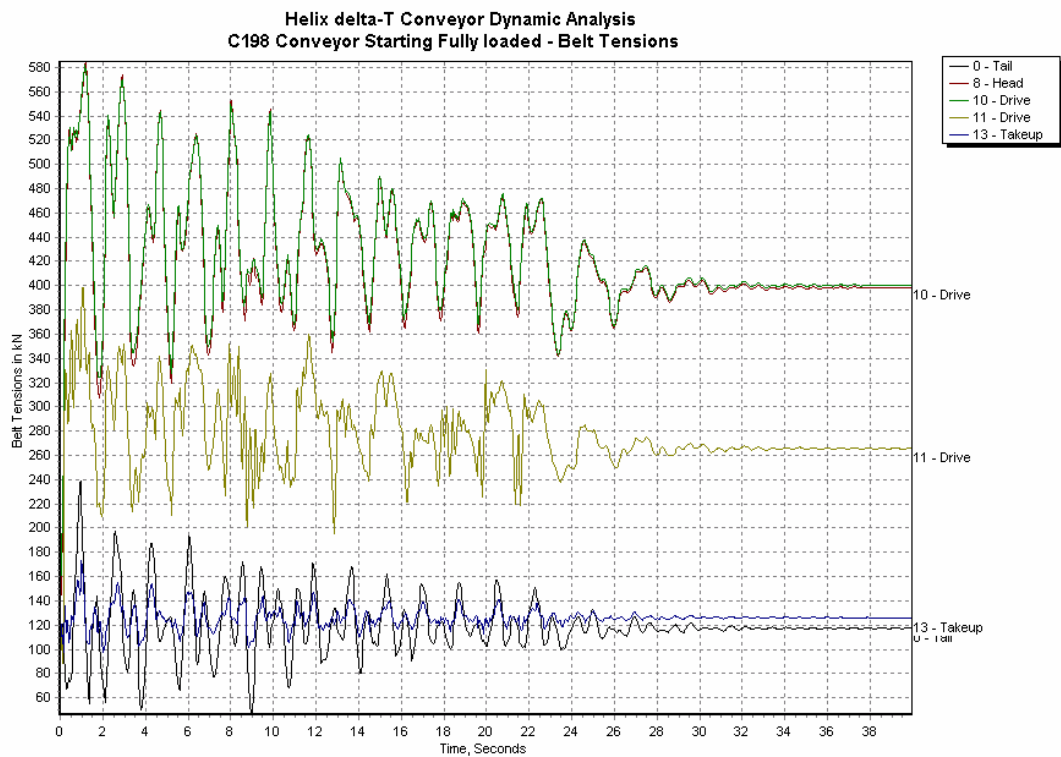### 5.3.3   Belt Velocities

Conveyor starts in about 22 seconds

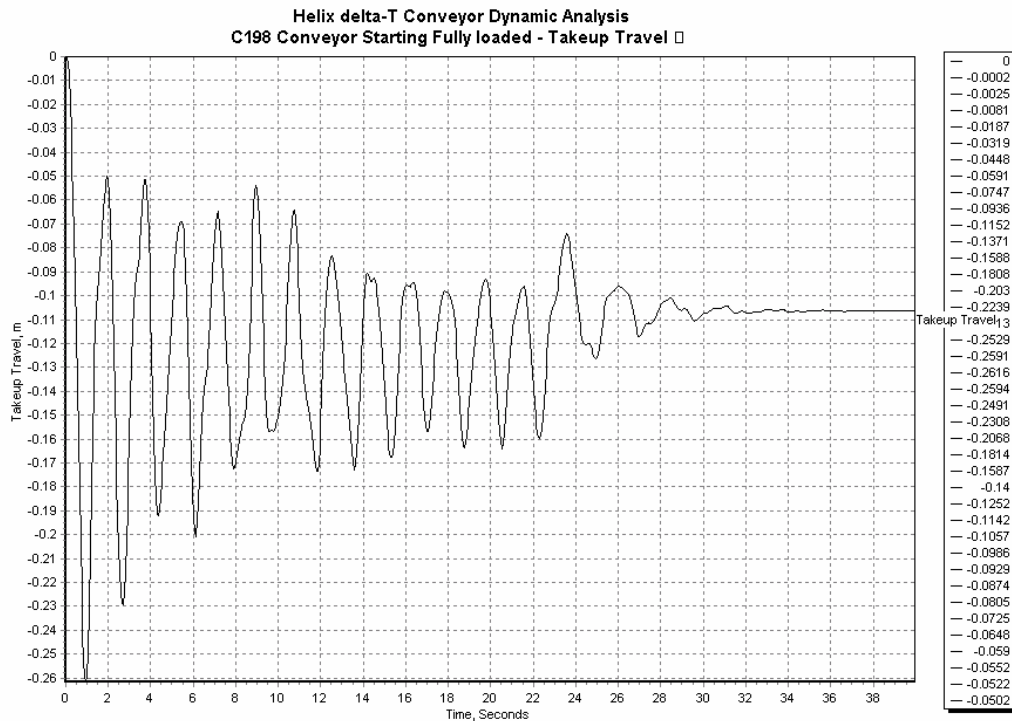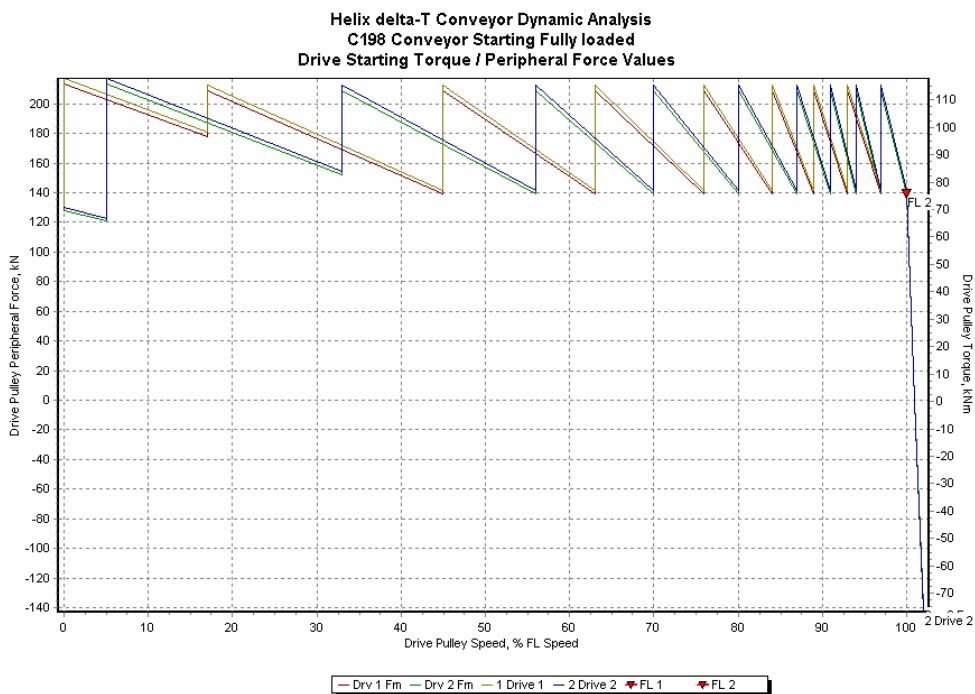### 5.3.4   Belt Velocities - Zoomed view

5.3.5   Belt Tensions

Note some high frequency load changes at the secondary drive between 8 to 10 seconds and

again at about 18 seconds. This is occurring at 9/22 = 41% of full speed and 18/22 = 82% of full load speed and appears to be when drive one has a relatively low tension.
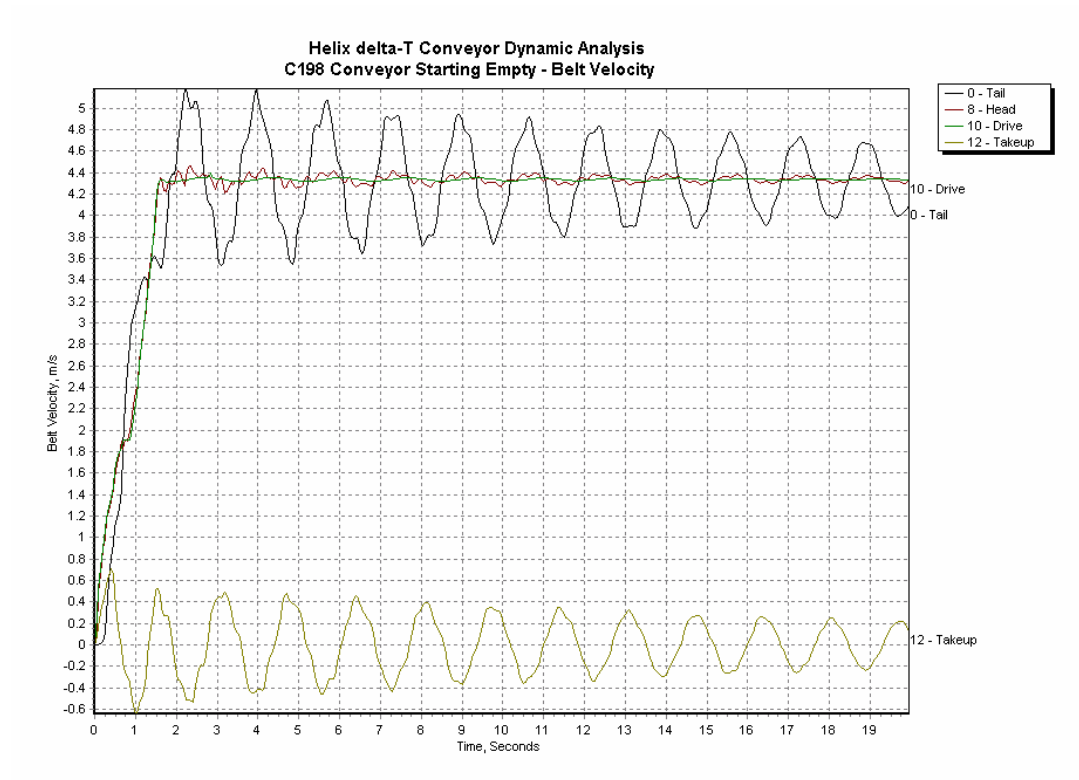
5.3.6   Takeup Travel
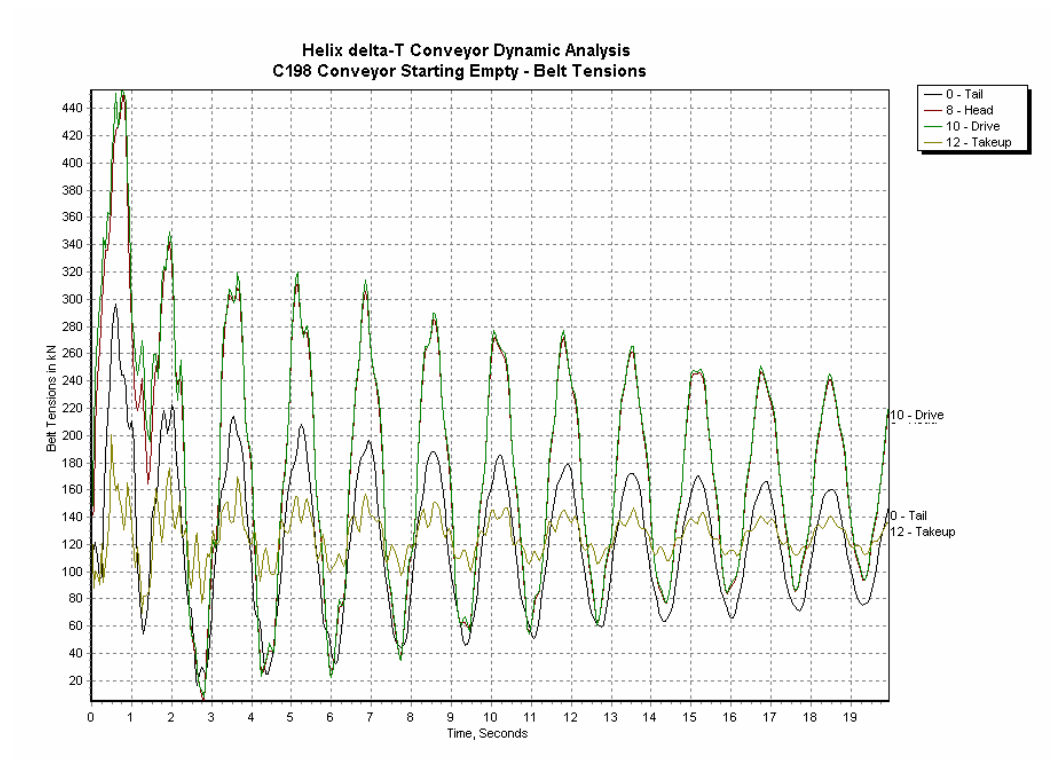

5.3.7   Drive Torque

5.4 **Case 3 Starting Empty - 1 Drive Pulley**
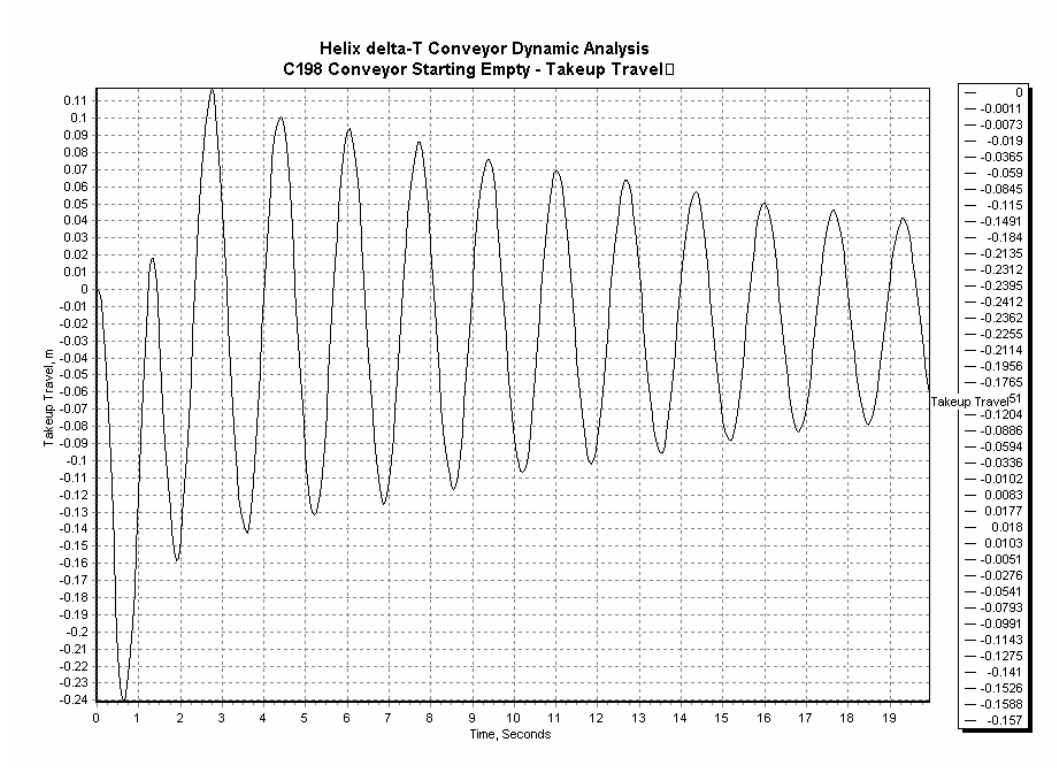
5.4.1 Belt Velocities

Starting time Empty with one drive about 2 seconds at the drive.
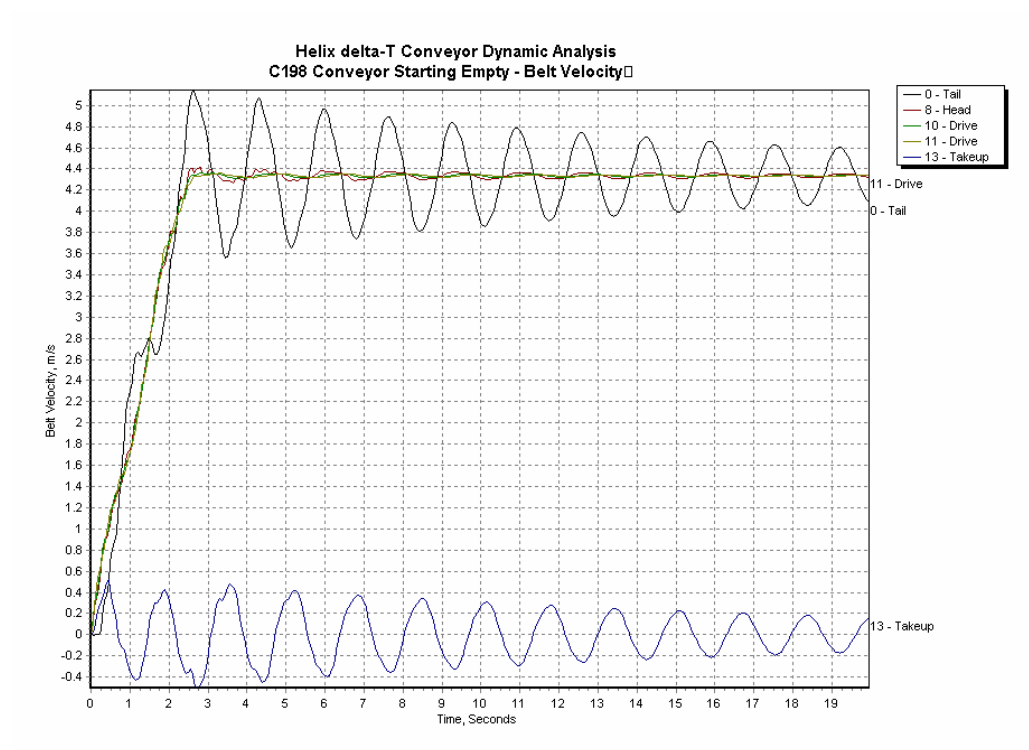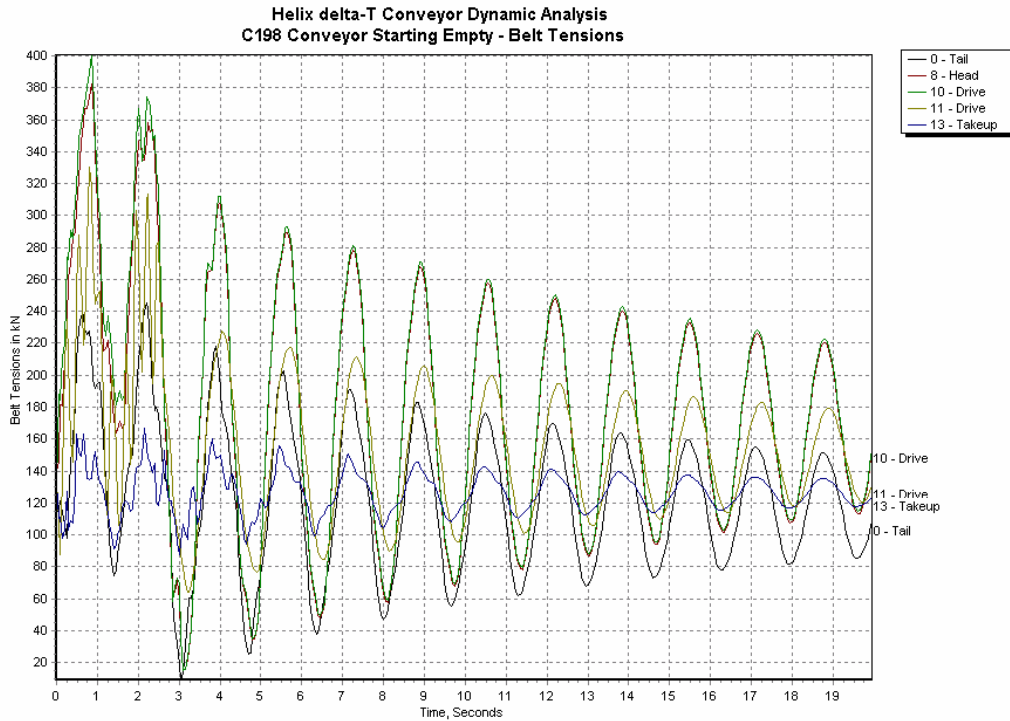
5.4.2 Belt Tensions

5.4.3   Takeup Travel
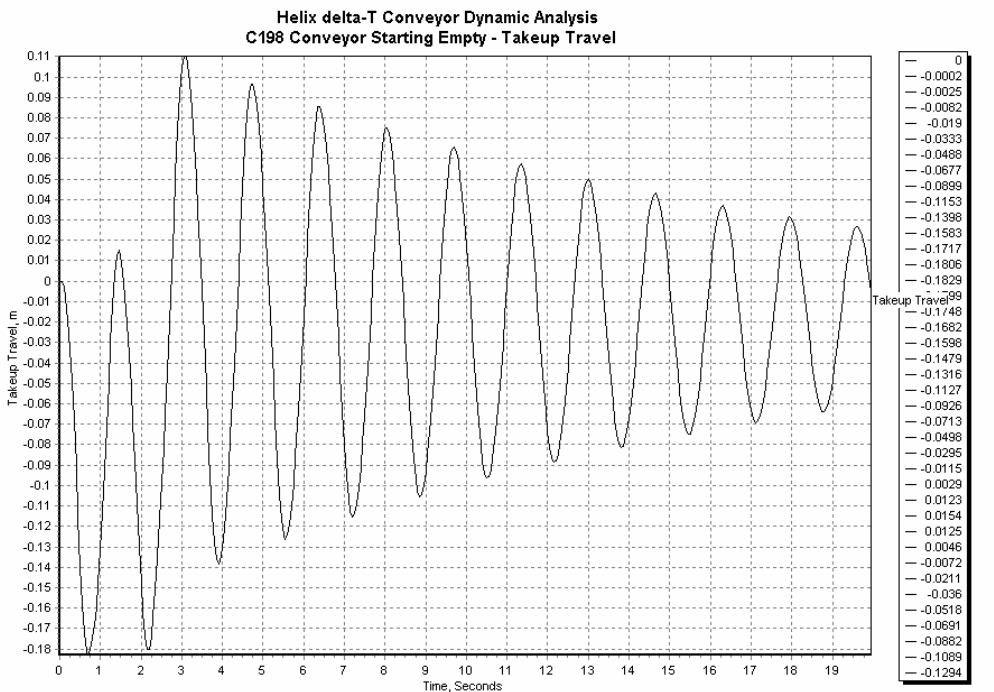

5.5   **Case 4 Starting Empty - 2 Drive Pulleys**

5.5.1   Belt Velocities

5.5.2   Belt Tensions

5.5.3   Takeup Travel

5.5.4   Drive Torque Speed

Helix delta-T Conveyor Dynamic Analysis
C198 Conveyor Starting Empty
Drive Starting Torque / Peripheral Force Values
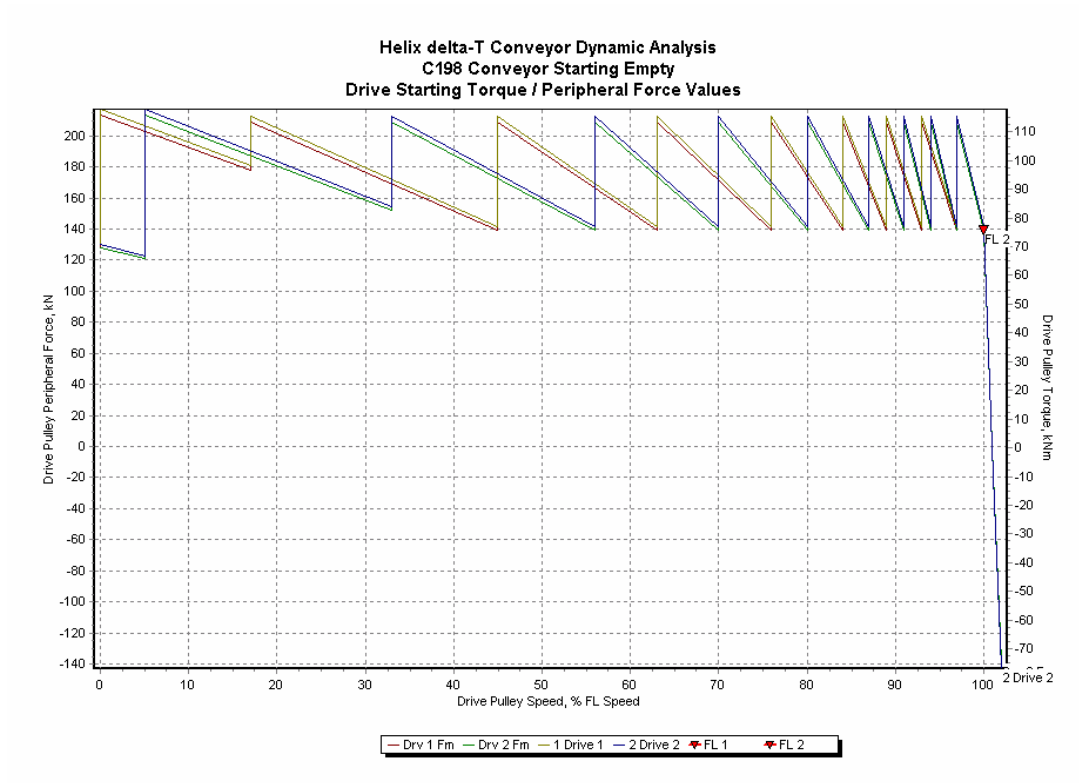
5.6 Case 5 Stopping Fully Loaded, single drive pulley

5.6.1 Belt Velocity

Helix delta-T Conveyor Dynamic Analysis
C198 Stopping - Braking Fully loaded - Belt Velocity
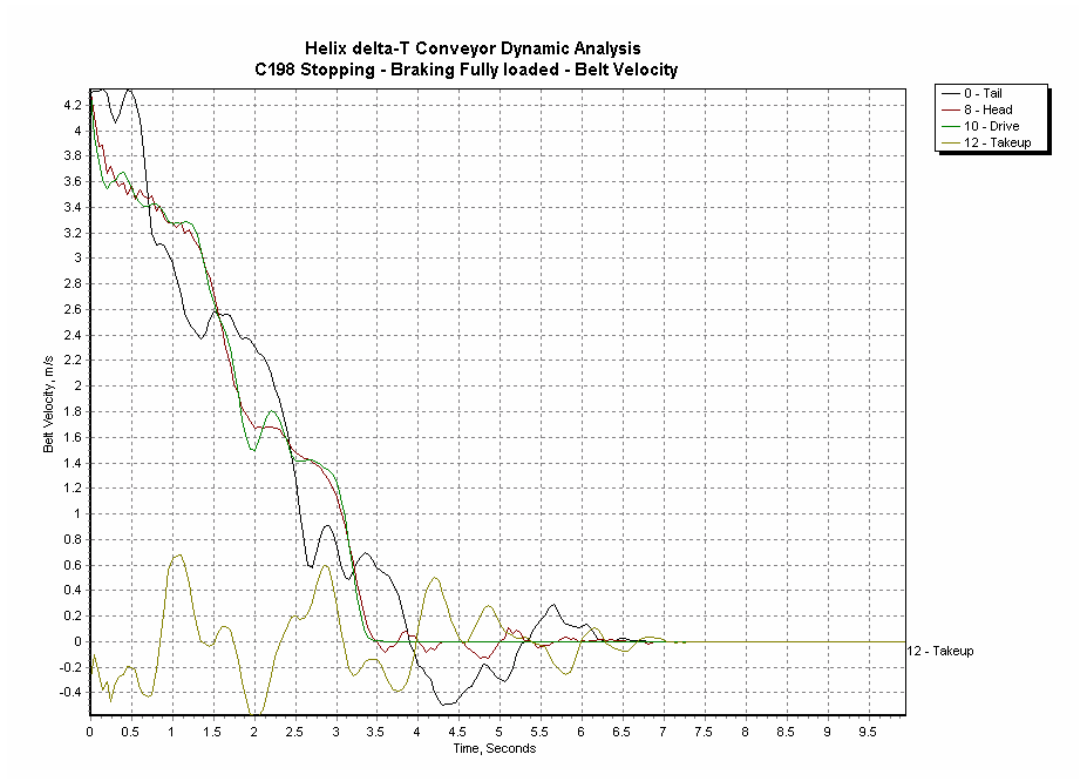
Drive stops in 3.6 seconds; tail continues on and also runs in reverse for a short time.

5.6.2 Belt Tensions
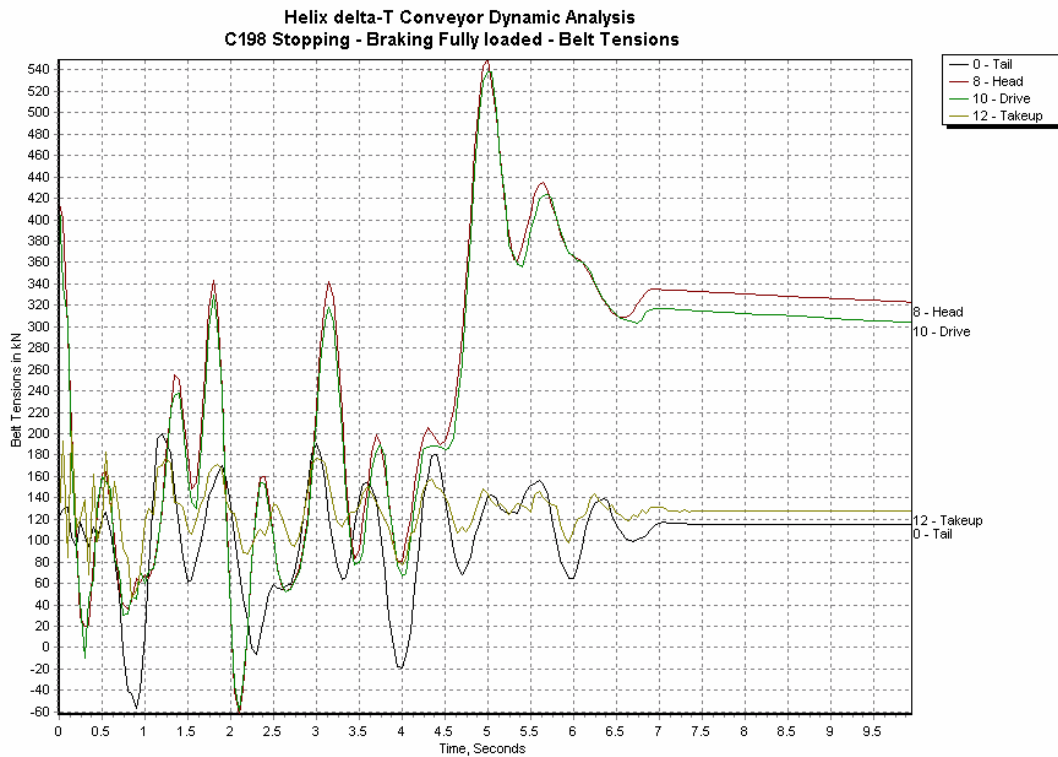
Note Tension rise at Drive and Head pulley as Holdback locks into place. Each drive has a separate holdback device, rated to 42.5kNm each.
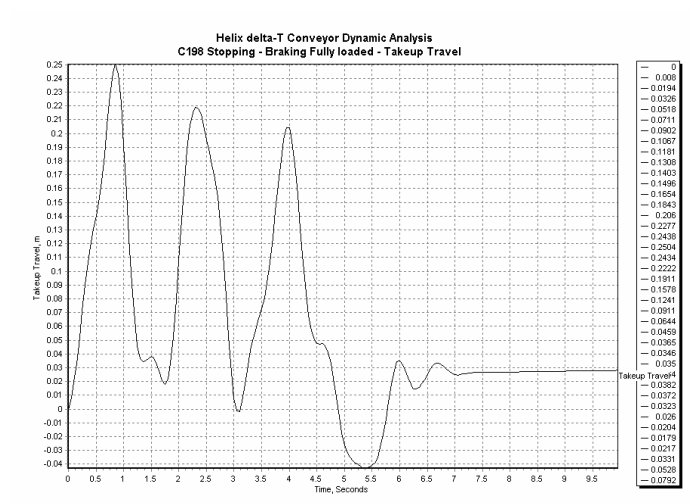
If only one holdback takes all load, then (540 - 131kN) = 409kN force on gearbox.

Pulley diameter of 1024mm = 209.4kNm. Gearbox rating is 941.8kW at L.S. shaft speed of 81.9rpm.

Therefore torque rating of gearbox is calculated as 941.8 x 9550 / 81.9 = 109.8kNm.

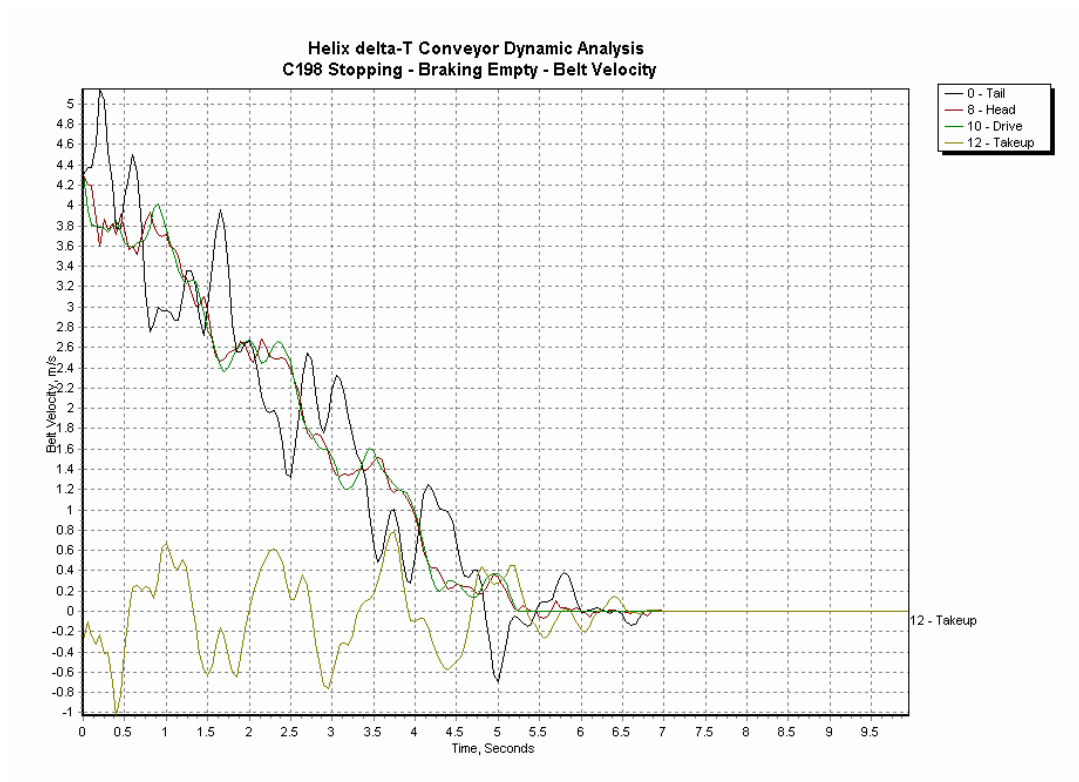Holdback force exceeds gear rating by a factor of 209.4/109.8 = 1.907.

5.6.3 Takeup Movement

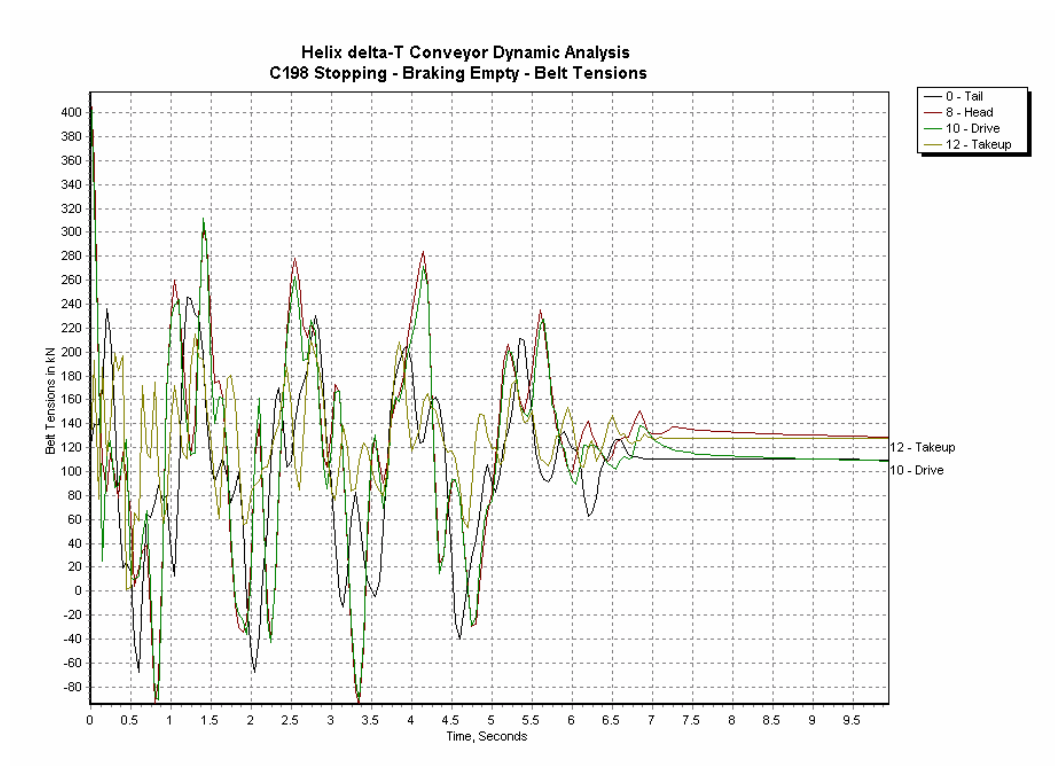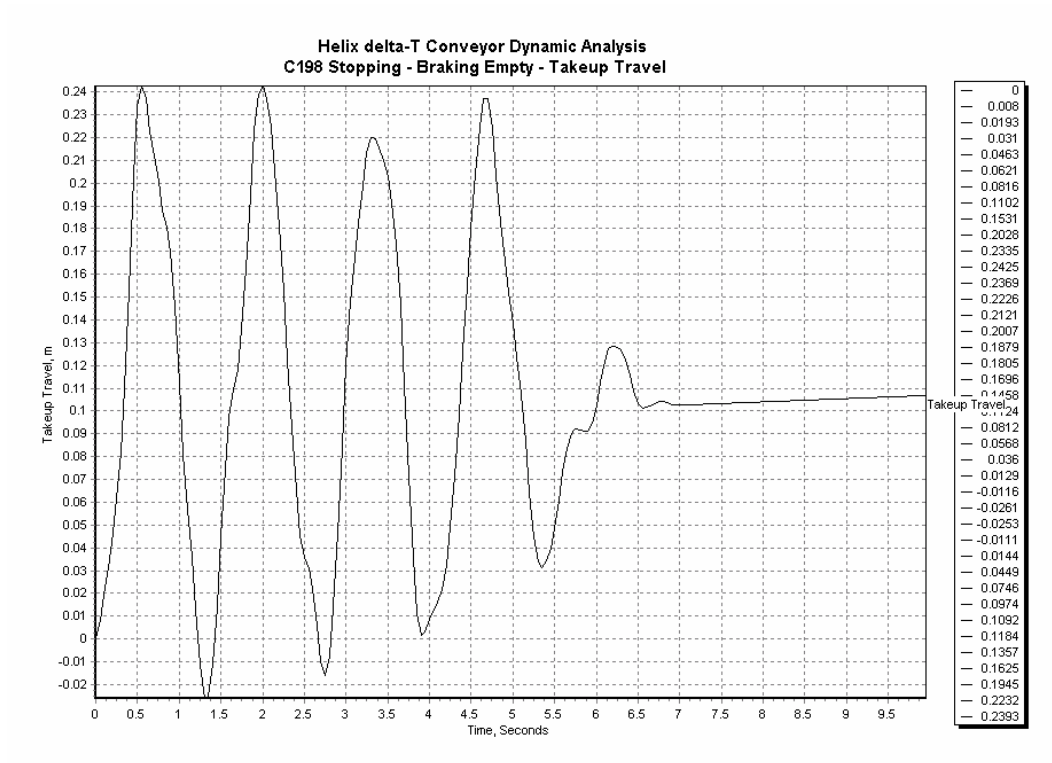## 5.7 **Case 6 Stopping Empty, single drive pulley**

5.7.1 Belt Velocity

5.7.2 Belt Tensions

5.7.3 Takeup Movement

Helix delta-T Conveyor Dynamic Analysis
C198 Stopping - Braking Empty - Takeup Travel

6   **SUMMARY AND CONCLUSIONS**

Examination of the design reports allows the following main points to be made:

- The conveyor is capable of carrying the load capacity of 9400tph.

- Installed power of 1260kW is on the low side and conveyor may not be capable of carrying 9400tph over extended periods due to motor overloading.

- Belt Rating is adequate.

- Gearbox torque rating during a fully loaded start is inadequate if the gear rating is 941.8kW at 81.9rpm. Calculated service factor during a fully loaded start is only 0.915.

- Gearbox torque rating for holdback condition may be inadequate. If holdbacks do not load share, then one gearbox will have to take a torque of 209.4kNm and this is 1.9 times the gear rating.

7   **APPENDICES**

The following files in electronic file format make up the appendices to this report.

7.1   **CV202 Static Design Reports.pdf**

This report shows all the main input data for the conveyor as well as the 'rigid body' or 'static' design reports.

7.2   **CV202 Dynamics Case 1 Starting Full.pdf**

Dynamic Analysis results.

7.3   **CV202 Dynamics Case 1 Starting Full 3D Belt Tensions.pdf**

Dynamic Analysis results.

7.4   **CV202 Dynamics Case 2 Starting Full.pdf**

Dynamic Analysis results.

7.5   **CV202 Dynamics Case 3 Starting Empty.pdf**

Dynamic Analysis results.

7.6   **CV202 Dynamics Case 4 Starting Empty.pdf**

Dynamic Analysis results.

7.7   **CV202 Dynamics Case 5 Stopping Braking Fully Loaded.pdf**

Dynamic Analysis results.

7.8   **CV202 Dynamics Case 6 Stopping Braking Empty.pdf**

Dynamic Analysis results.

7.9   **BTCV202 Dynamics Case 5 Stopping Braking Fully Loaded.pdf**

Dynamic Analysis results.