CONVEYOR STRUCTURE DESIGNED FOR CONVEYING RUN OF MINE MATERIAL; RIGHT, WRONG OR WRONGFULLY RIGHT?

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BACKGROUND:

The soft rock mining industry has developed a set of belt conveyor support structures and considers their equipment to be superior to anything else available.

The hard rock mining industry has similarly developed a set of belt conveyor support structures and considers their equipment to be the best there is.

Like everything else developed by man, no matter how brilliantly it performs for a time, inevitably its technology will be superseded.

The purpose of this paper is to briefly examine and review both types of equipment presently in use and recommend a constructive way forward as improvement must of necessity, be an ongoing commitment.

ASSUMPTIONS:

This paper has been developed from knowledge and observations limited to the South African industry only.

A belt width of 1050 was taken as being common to both hard and soft rock mining applications. The idlers would be three rolls troughing, at thirty five degrees, to SANS 1313.

A common lump size of 600 x 600 x 800 was assumed.

DISCUSSION:

SOFT ROCK MINING:

The soft rock mining industry has been using conveyors far longer than the hard rock mining industry. A typical coalmine could have anything from 20 to 60 kilometres of conveyors in operation. These conveyors on average convey material at a rate of 1000 to 2200 tons per hour at speeds from 2,5 to 4,5 meters per second. Common belt widths are 1050, 1200, 350 and 1500. The tendency in the industry is for the belt speed to be accelerated as capacity requirements increase. Belt widths of 1650mm operating at speeds of 4,5 m/s carrying 4500 tons per hour are currently being installed and will soon be the norm.

The typical idler profile is fixed form suspended or link suspended idlers on the carrying side with vee return rollers on the return strand. The return strand idlers would normally be one size larger than the installed belt width to allow for additional clearance. Support stools would be manufactured from angle, channel or tubular sections. Stringers would also be manufactured from angle, channel or tubular sections.

HARD ROCK MINING:

The hard rock mining industry have, with the improved toughness and durability of belting and equipment, changed its approach to conveyors and is constantly moving towards increasing the use of this equipment. Due to the nature of the mining, there would be 4 to10 kilometres of conveyors in operation. These conveyors, on average, convey material at a rate of 100 to 500 tons per hour at speeds from 1 to 2,25 meters per second. Common belt widths are 750, 900 and 1050. The tendency in this industry is also for the belt speeds to be marginally increased.

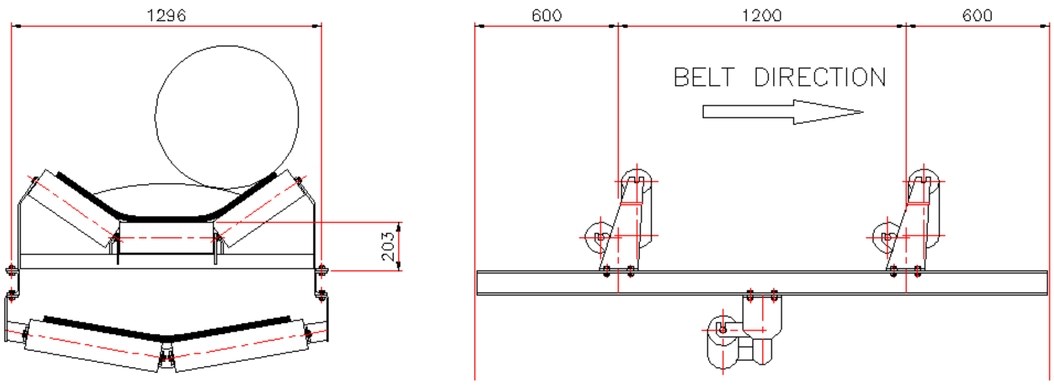
There is presently a limit to the required capacity of the conveyors in this sector of the industry, as hard rock mining is difficult and mining methods have not yet reached the point where vast production capacities could be realised.

The typical idler profile is mounted bases on the carrying side, with flat or 10 degree vee return rollers on the return strand. Both the troughing and return idlers comply to SANS 1313 part 1. The troughing idler configuration and the return idler configuration are for the same belt width. Support stools would usually be manufactured from angle, channel or tubular sections. Stringers would also be manufactured from similar sections.

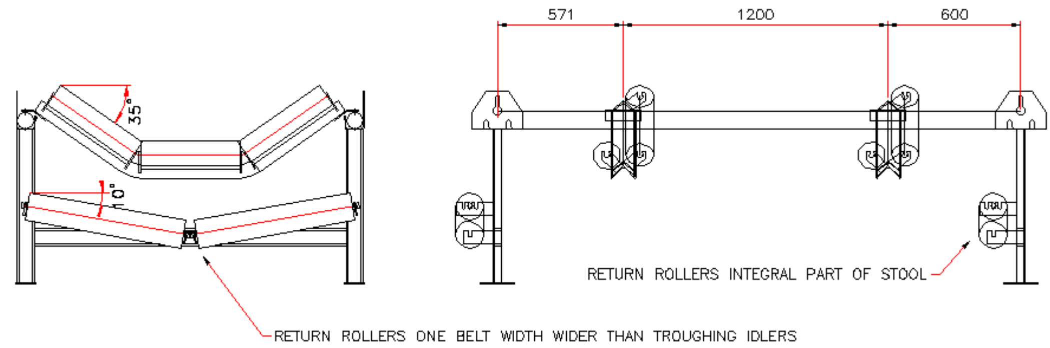
DESIGN REQUIREMENTS:

The design of a support structure must be such that it will support the worst loading condition from a bending point of view. The structure must allow for and remain square whenever out of balance forces occur, that would otherwise deform the structure.

Modern day design methodology will use the limit state approach for sizing members that will adequately support the conveyor loads within acceptable bending and deflection constraints. A percentage of the vertical load is assumed as being the out of square force that would cause distortion. The hard rock industry is diligently following these criteria while the soft rock industry has mostly long forgotten the out of square forces in the system.



TYPICAL HARD ROCK RUN OF CONVEYOR STRUCTURE

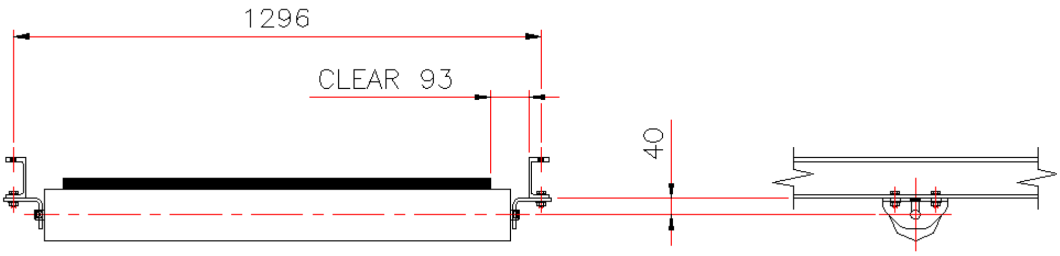


TYPICAL SOFT ROCK RUN OF CONVEYOR STRUCTURE

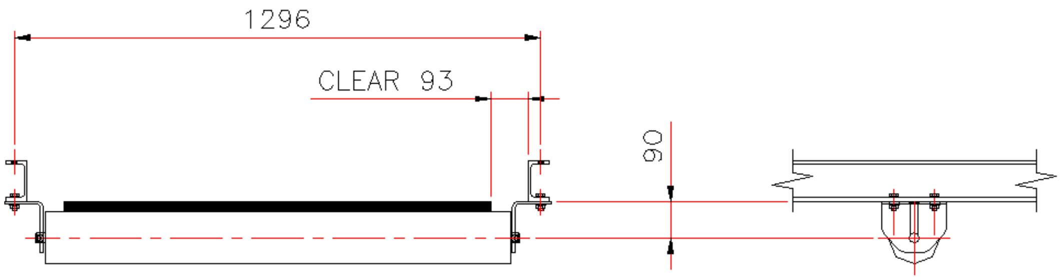
SANS 1313 REQUIREMENTS

A buzzword in the industry is SANS 1313. Whatever happens, the perception is that the structure must comply with this specification. In real terms, SANS 1313 is essentially a guide, to envelope sizes for interchangeability and not a performance specification.

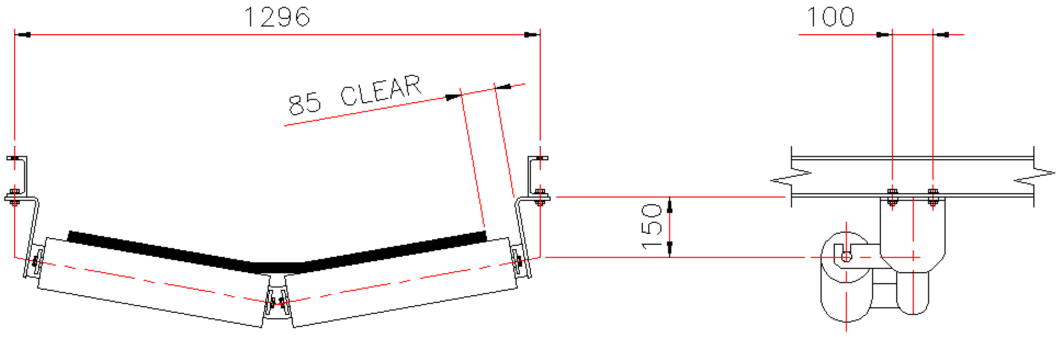
The national specification refers to flat return rollers as being either a 40 or 90 drop height. It also notes vee return rollers as having a 150 mm height from the centre line of the roller to the underside of the stringer. (Please refer to the following sketches)



FLAT RETURN IDLER TO SANS 1313 PART 1
CONVENTIONAL BRACKETS
STANDARD CLEARANCES

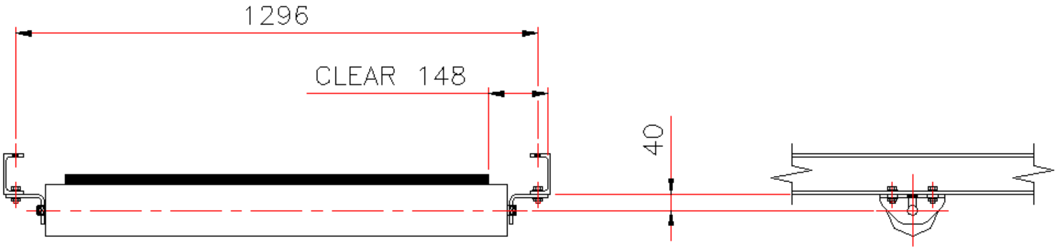


FLAT RETURN IDLER TO SANS 1313 PART 1
CONVENTIONAL BRACKETS
STANDARD CLEARANCES

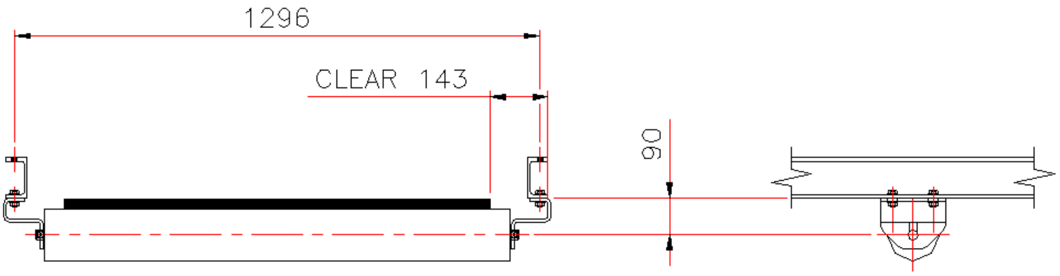


VEE RETURN IDLER TO SANS 1313 PART 1
CONVENTIONAL BRACKETS
STANDARD CLEARANCES

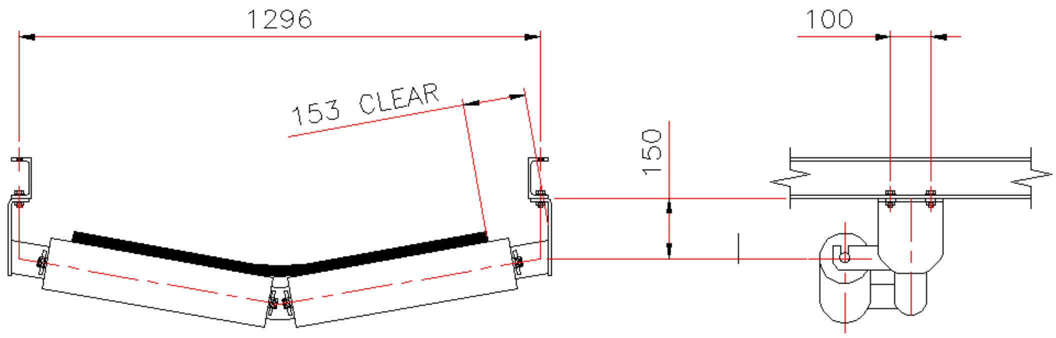
What the industry requires, is that the rollers must supply maximum clearance for maximum float of belt.



FLAT RETURN IDLER TO SANS 1313 PART 1
STRINGER ORIENTATION MODIFIED
FOR INCREASED CLEARANCES



FLAT RETURN IDLER TO SANS 1313 PART 1
DROP BRACKET GEOMETRY MODIFIED
FOR INCREASED CLEARANCES

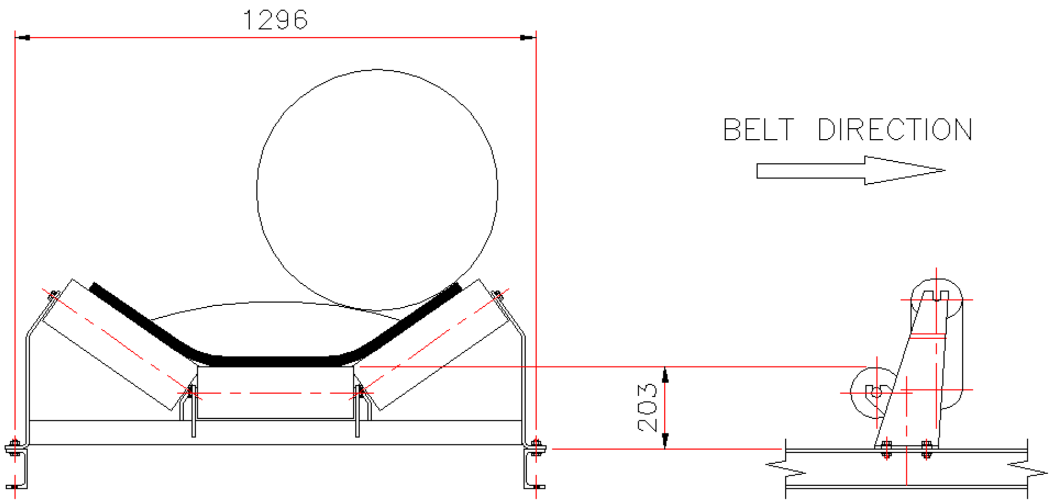


VEE RETURN IDLER TO SANS 1313 PART 1
DROP BRACKET GEOMETRY MODIFIED
FOR INCREASED CLEARANCES

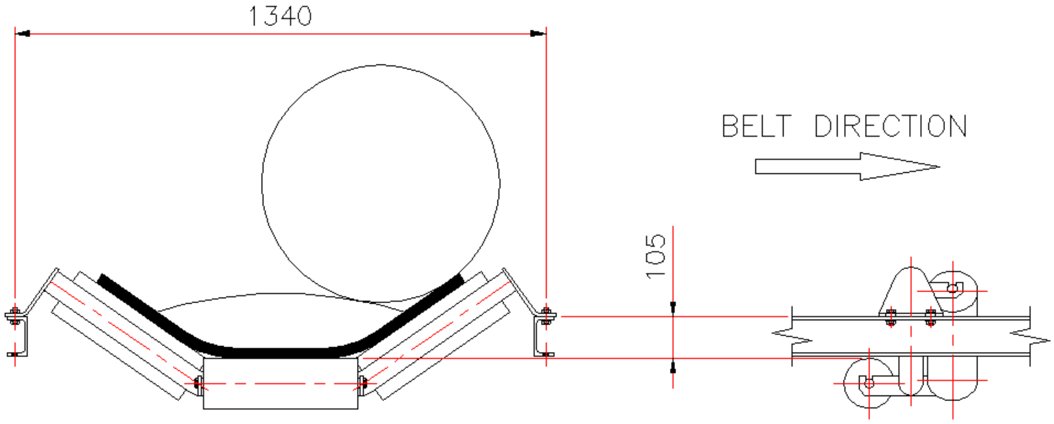
The same applications are now modified to suit the industry requirements. The soft rock industry has adopted this practice. They tend to have a norm whereby the return rollers are specified as being one size up from the troughing side. If the troughing side is 1050 belt width, 1200 belt width idlers are called for and supplied. In real terms the fixing centres of the troughing side differs 152 mm from the return side.

The question that remains is whether the standard cannot cater for both these requirements? SANS 1313 part 2 is normally overlooked. In this standard there is a product referred to as a fixed form suspended type idler. These units have fixing centres that are wider than those for mounted type idlers. (Please refer to the table below for the differences)

BELT WIDTH	**FIXING CENTRES**		**DIFFERENCE**
	SANS 1313 PART 1	**SANS 1313 PART 2**	
600	838	890	52
750	990	1040	50
900	1144	1190	46
1050	1296	1340	44
1200	1448	1490	42
1350	1600	1640	40
1500	1752	1790	38
1650	1904	1940	36

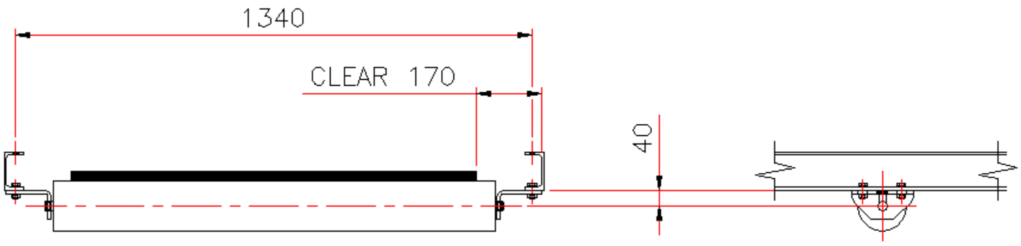


TROUGHING IDLER TO SANS 1313 PART 1

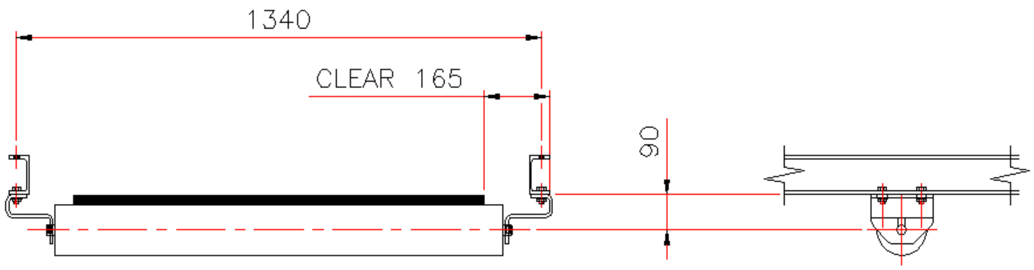


TROUGHING IDLER TO SANS 1313 PART 2

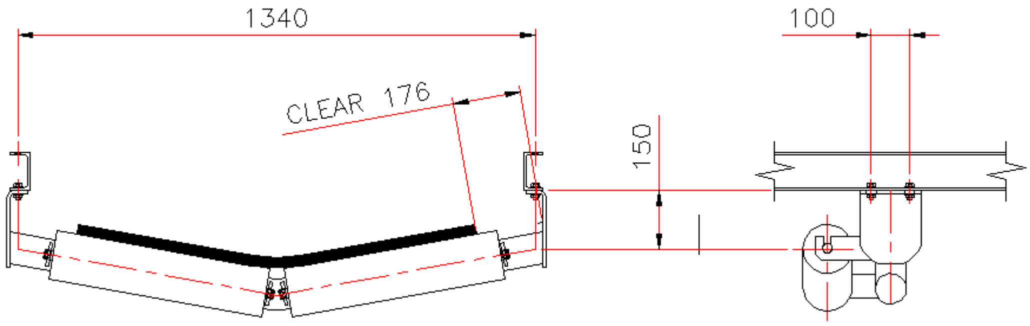
With the correct bracket orientation the additional “152 mm” belt float clearance is readily available.



FLAT RETURN IDLER TO SANS 1313 PART 2
STRINGER ORIENTATION MODIFIED
FOR INCREASED CLEARANCES



FLAT RETURN IDLER TO SANS 1313 PART 2
END BRACKETS MODIFIED
FOR INCREASED CLEARANCES



VEE RETURN IDLER TO SANS 1313 PART 2
END BRACKETS MODIFIED
FOR INCREASED CLEARANCES

DESIGN OF IDLER BASES

Idler bases are designed with the assumption that two thirds of the load is on the centre roller. The loading on the wing roller is only required to be one sixth of the load supported by the idler.

Using the 1050 belt width example and an idler pitch of 1200mm:

Soft rock:

Material broken density of 1000 kg per cubic metre.
Insitu density of 1300 kg per cubic metre.
Surcharge angle of 15 degrees.
Belt speed of 4,5 m/s.
From the attached graph:
Full belt capacity is 1000 tons per hour.

Calculate equivalent material loading on idler base
Idler loading = conveyor capacity x 1000 ÷ 60 ÷ 60 ÷ belt speed x idler pitch.
= 1000 tph x 1000 ÷ 60 ÷ 60 ÷ 2,5 m/s x 1,2 m
= 133,3 kg

Calculate centre roller loading
Roll loading = 2/3 x idler loading
= 2/3 x 133,3
= 88,9 kg

Calculate wing roller loading
Roll loading = 1/6 x idler loading
= 1/6 x 133,3
= 22,2 kg

Calculate the mass of a lump 600 x 600 x 800.
Lump mass = volume of mass x density.
= 0,6 x 0,6 x 0,8 x 1300
= 374,4 kg.

Hard rock:

Material broken density of 2300 kg per cubic metre.
Insitu density of 3400 kg per cubic metre.
Surcharge angle of 15 degrees.
Belt speed of 2,25 m/s.
From the attached graph:
Full belt capacity is 1000 tons per hour.

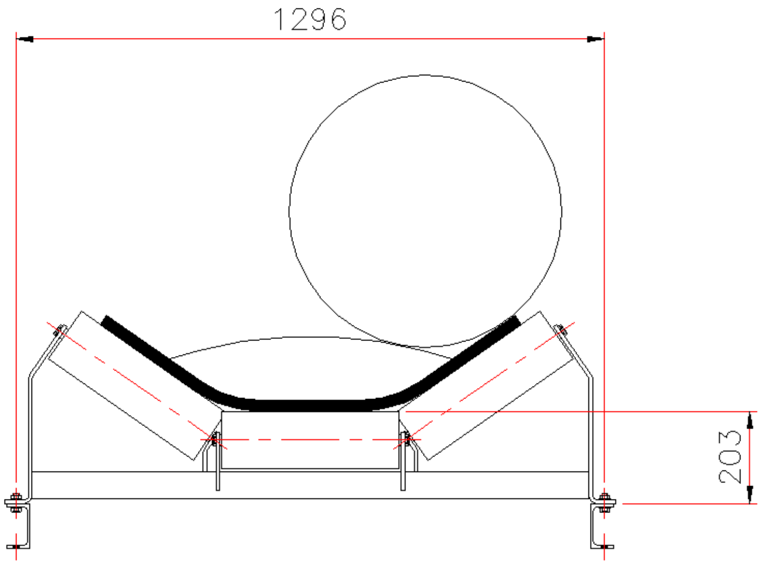
Calculate equivalent material loading on idler base
Idler loading = conveyor capacity x 2300 ÷ 60 ÷ 60 ÷ belt speed x idler pitch.
= 1000 tph x 1000 ÷ 60 ÷ 60 ÷ 2,5 m/s x 1,2 m
= 133,3 kg

Calculate centre roller loading
Roll loading = 2/3 x idler loading
= 2/3 x 133,3
= 88,9 kg

Calculate wing roller loading
Roll loading = 1/6 x idler loading
= 1/6 x 133,3
= 22,2 kg

Calculate the mass of a lump 600 x 600 x 800.
Lump mass = volume of mass x density.
= 0,6 x 0,6 x 0,8 x 3400
= 979,2 kg.

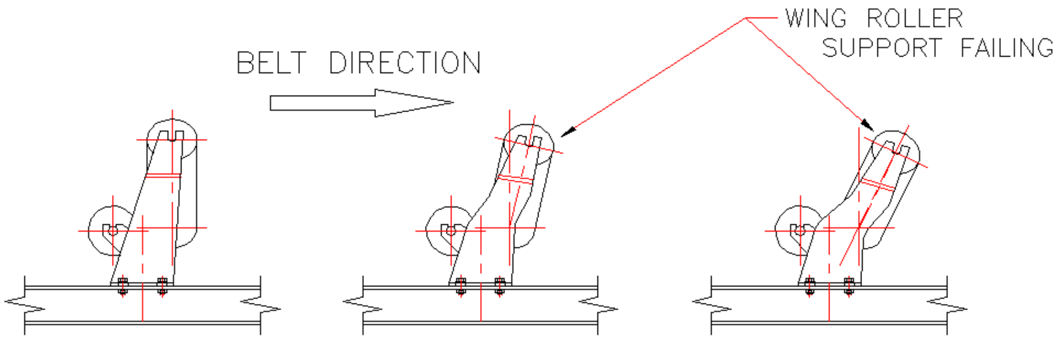
But where does a lump reside on a conveyor belt? In accordance with present design convention it should be in the centre. This statement, as you've probably already guessed, is incorrect. A lump will roll down to the lowest point of support. This point is not on top of the material pile, but always on the sides. (Please refer to the attached sketch for clarification)



LARGE LUMP IN SYSTEM

The lump sitting on the edge of the material induces a load of 979,2 and 374,4 kg on the wing roller. The equivalent design load on these units is 22,2kg in both cases. It is obvious from the aforesaid that bases used in the industry could well be seriously under designed.

This point is frequently evident and clearly visible on many installations in the industry. Pictures of these failures, although available, cannot be displayed in this forum, as equipment from the various idler manufacturer's are readily identifiable. Please refer to the following sketches to illustrate the principle mode of failure.



PROGRESSIVE FAILURE MODE
WING ROLLER COLLAPSING

Now consider the simplicity of the solution. When a fixed form suspended idler base is used, there are two distinct advantages. The technical advantages are that there is no vertical support that can be subjected to failure. The financial advantage is, that it is more economical. The ultimate solution, a unit that is stronger and yet cheaper.

Before anyone gets carried away and starts using these units throughout, a caution, there is a problem with gantries. Box type gantry designs do not lend themselves to using this product. In essence a full stringer section is required over the full length of the gantry section. This is costly. The correct solution is believed to be a standard extra heavy-duty idler base that is classed as a run of mine base. The difference in the design is that the side bracket of the base is of extra heavy-duty construction in accordance with the loading requirements.

The recommendation is that there needs to be differentiation between types of idler bases relative to application. Standard industrial type bases are required for sized material. The next level up requires a heavy-duty base, designed for unsized soft rock, run of mine material. The top of the range will be an extra heavy-duty base designed for unsized hard rock, run of mine material.

CLEARANCES

Site conditions dictate accuracy of installation. Underground conveyors cannot be installed as accurately as their surface counterparts. This is fact. Underground conveyors understandably then require larger operating clearances than surface conveyors.

The soft rock mining industry acknowledges this criterion. In the majority of the cases they specify the return idler assembly as being one size up from the troughing belt. Typically 1350 return roller would be used on a 1200 wide belt installation.

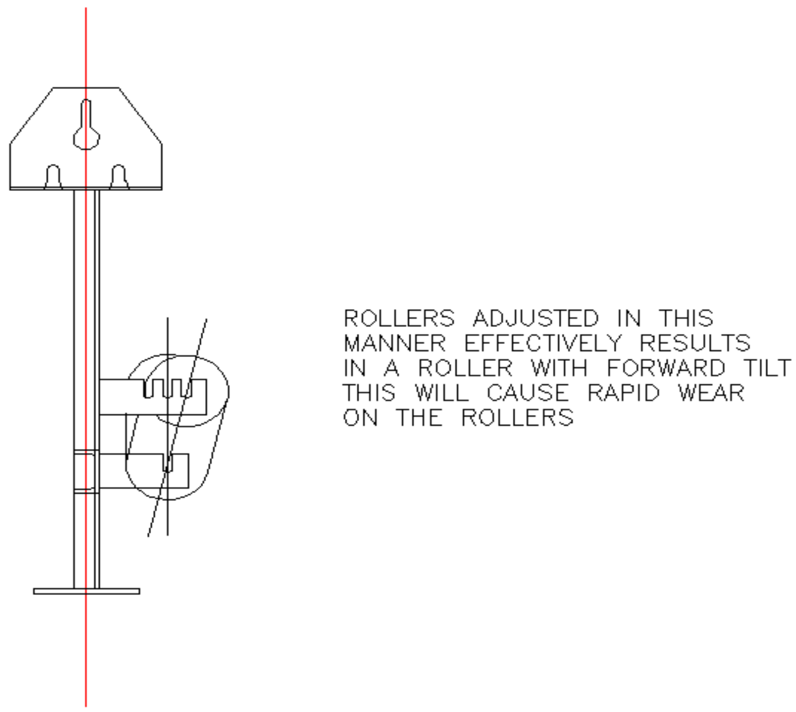
The relatively wider fixing centres of the fixed form, suspended type idlers should be used on all underground conveyors while the standard heavier duty type bases should be used on gantry type surface application for unsized materials.

Although two different idler bases are being recommended, the rollers remain the same. Maintenance will thus not be an issue as the rollers are fully interchangeable between the two idler types.

VEE RETURN IDLERS

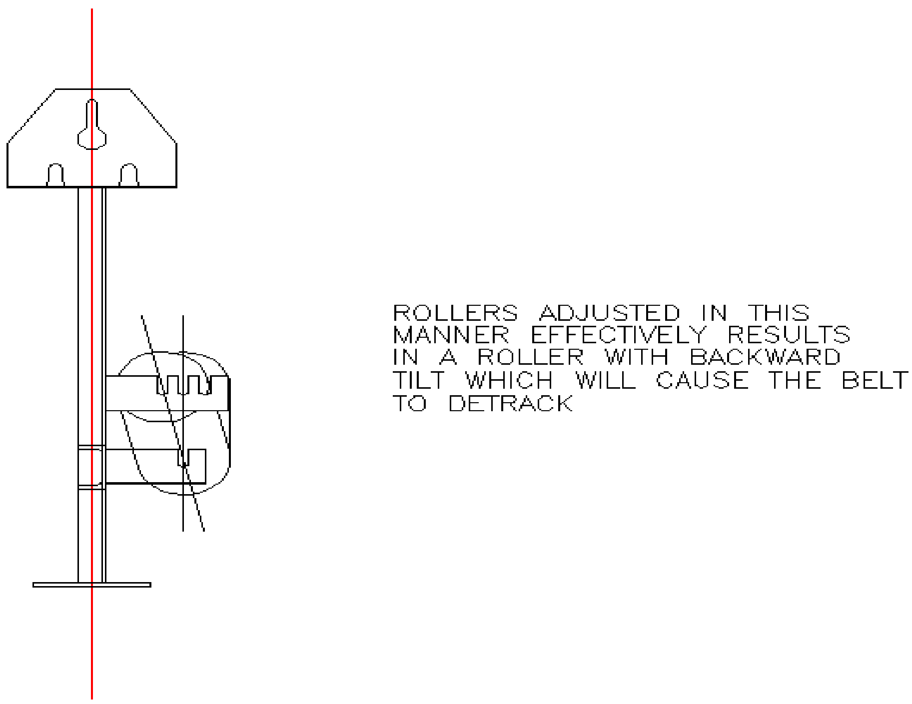
Here is a subject that is just as controversial. The convention in the soft rock mining industry is to make this item part and parcel of the stool. This is perceived by many designers to be a major problem and the cause of rapid shell wear. Consider the geometry of the installation.

The roller is in line in the neutral position on the stool. The belt is found to be running out of line. If the one roller is moved forward in the direction of belt travel, the result is similar to that of an excessive forward tilt of the roller. The rollers are now acting against one another and are forcing the belt into the vee. Tracking is achieved but it is combined with rapid wear.



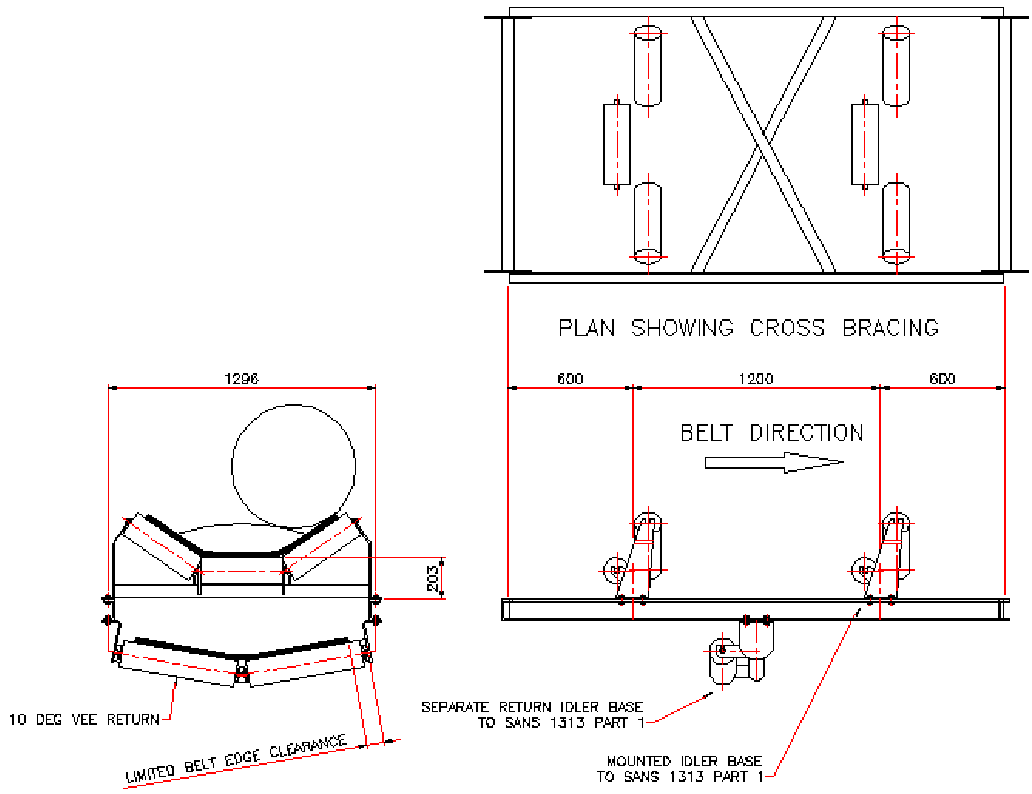
N/S ROLL FORWARD
F/S ROLL NEUTRAL

Should the same roller be moved backwards, against the direction of belt travel, the result is similar to that of an excessive backward tilt. The belt is now being forced out of the vee and causing the belt to de-track.



N/S ROLL BACKWARD

The correct way of tracking the belt would be to move both the vee return rollers in the same direction. There is no possibility of detracking the belt or of creating an excessive roller wear situation. The capital saved by buying the integral unit soon turns into a substantial negative, due to the increase in replacement costs of return rollers.

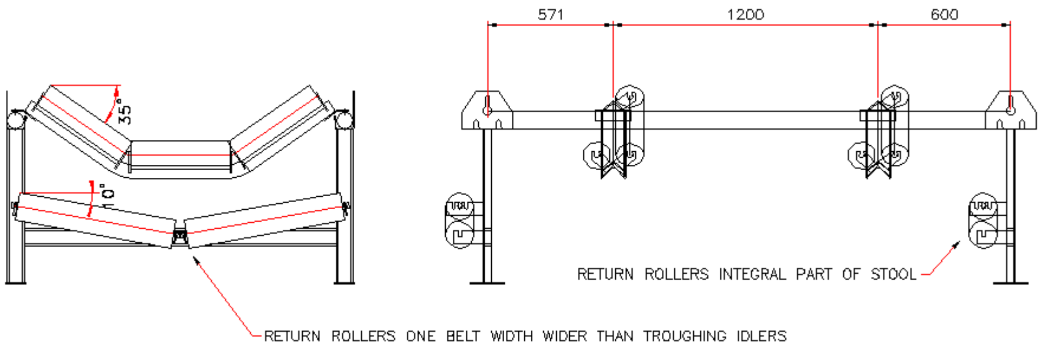


TYPICAL HARD ROCK RUN OF CONVEYOR STRUCTURE

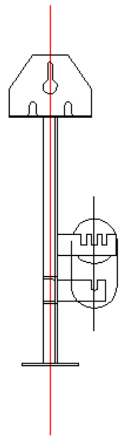
BRACING REQUIREMENTS

The designer of run of conveyor structure must ensure the installation remains square under all operating conditions. The proposed use of fixed form suspended idlers again creates a problem, for it will no longer be possible to install bracing in the horizontal plane of the structure.

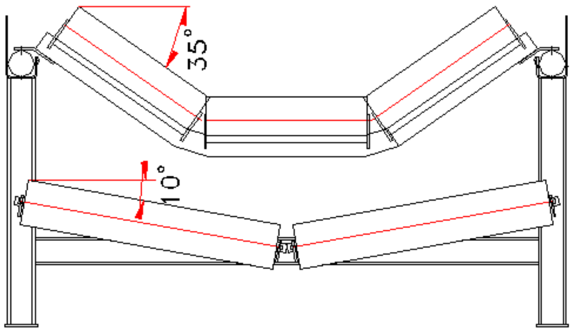
The hard rock installations insist on the bracing members (due to roof slinging), while the soft rock counterparts generally tend to ignore this requirement.



TYPICAL SOFT ROCK RUN OF CONVEYOR STRUCTURE

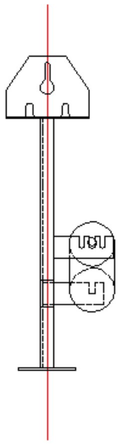


VERTICAL LEG

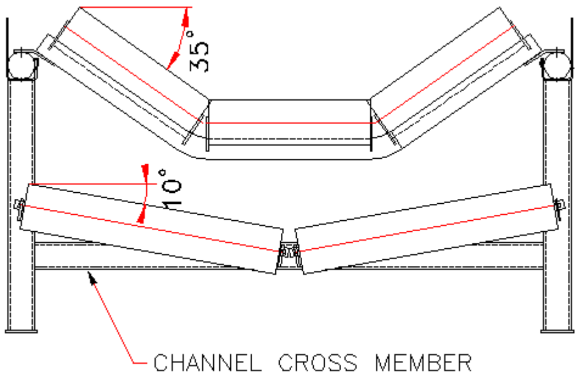


CROSS SECTION THRU STOOL

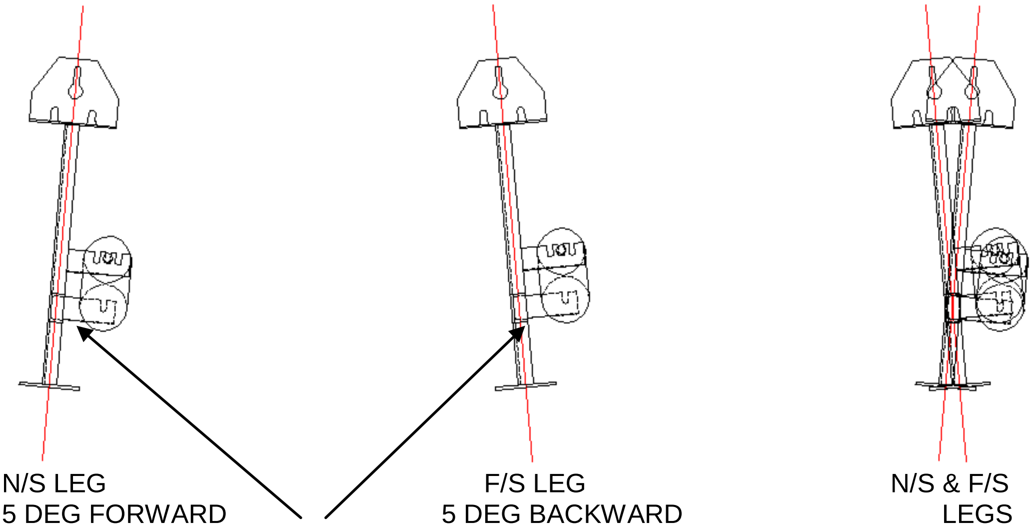
The accuracy of the latter is solely dependent on the accuracy of installation by the contractor. Invariably the stool legs are never parallel with one another. The one is either forward or backward to the one on the opposite side. The accumulation of error due to the variance in stringer length cannot now be compensated for. The relative position of the stringers determine where the connections will be.



VERTICAL LEG



CROSS SECTION THRU STOOL



INDUCED TORSION AFTER INSTALLATION

TORSIONAL MISALIGNMENT UNLIKELY (OR VERY LIMITED)
WITH TUBULAR CROSS MEMBER OF ADEQUATE SIZE

The way to resolve this issue is by using a cross member with torsion resistance. The construction of the stools should typically be that a tube of adequate size is used as a cross member. This member will ensure that the legs remain parallel.

CONCLUSIONS:

For un-sized run of mine material it is practically and economically justifiable to use fixed form suspended idlers.

More care should be taken when selecting and specifying the duty of mounted type idler bases in unsized material applications.

The practise of combining vee return bases into the stool construction is always problematic.

All underground support stools should be constructed with the cross brace being a member that can withstand torsion to act as a bracing member.

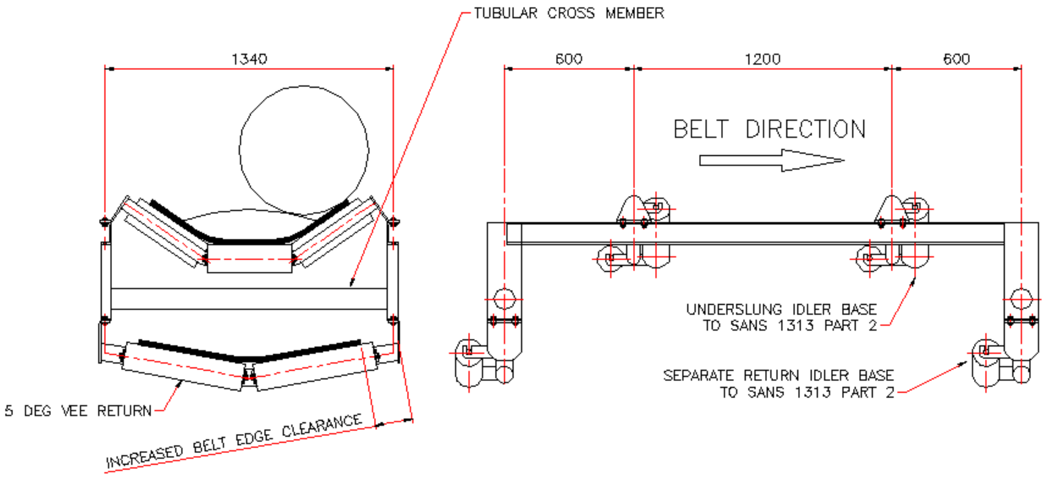
RECOMMENDATIONS:

Fixed form suspended idlers should be utilised for all underground applications.

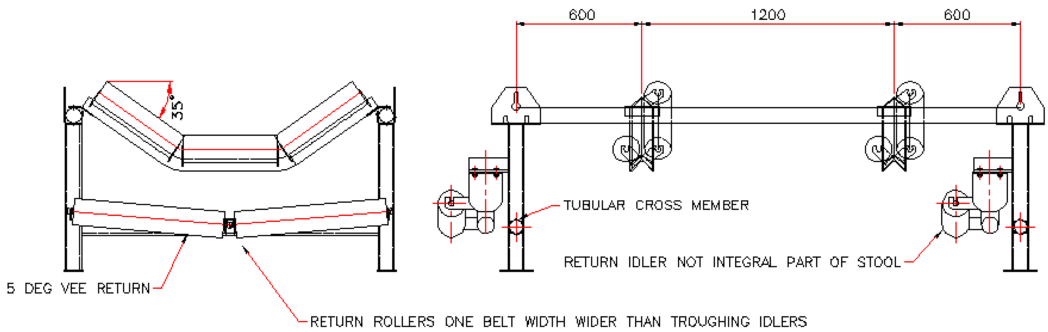
Mounted idler should be specifically classed and rated for the application. There should at least be an industrial base, a heavy-duty base and an extra heavy-duty type base.

All vee return idler applications should be fitted with independent idler bases and not be constructed as an integral part of the stool.

All stools must have tubular cross members to act as bracing members.



RECOMMENDED HARD ROCK RUN OF CONVEYOR STRUCTURE



RECOMMENDED SOFT ROCK RUN OF CONVEYOR STRUCTURE

REFERENCES:

Belt conveyor for bulk materials prepared by the Engineering conference of the Conveyor Equipment manufacturers association. (USA)

Recommended practice for trough belt conveyors prepared by the Mechanical Handling Engineers Association. (Britain)

SABS 1313 – 1:2002: Conveyor belt idlers Part 1: Troughed belt idlers (metallic and non-metallic) for belt speeds up to 5,0 m/s.

SABS 1313 – 2:1998: Conveyor belt idlers Part 2: Link suspended idlers and fixed-form suspended idlers