**Between the 2 end pulleys of a conveyor, the belt must be supported under the feed section, then throughout of conveyor, for the carrying and bottom sides.**

**What are the distances between all these idlers?**

**Technology of « long spacing »**

**Between the idlers of belt conveyors.**

This technology of the "long spacing"(1) between idlers was first developed, on the basis of an obvious, for the idlers of the return side in 1986. By analogy, the principle was extended to the idlers of the carrying side..

**"long spacing" between idlers: advantages & disadvantages! A long spacing it's winner!**

#### OBJECTIVES

The objectives, about of spacing between the idlers, are:

* **To guarantee a centered trajectory of the band, over the very long term and thus**:
	+ **reduce all costs related to instability of belt trajectory, such as**:
		- Soiling of the conveyor and the ground
		- the absorbed power by the device
		- untimely production stops
		- breakage and premature wear of components, including belt.
		- the lowest level of conveyor safety that results.

#### 1st EXPERIENCES OF ‘’LONG SPACING’’

In 1986, I used for the first time a "long spacing" on a raw flour metering conveyor of a cement factory. The distance between extremity pulleys of this conveyor was 6 m, with 3 return rollers with thin steel discs. These rollers were the cause of the premature wear of the belt, with a form of rut (**fig.1**) in the rubber coating, to the right of each disc. These ruts are the result of the high inertia of the rollers and the low belt pressure on the circumference of discs which imply a difference between the speed of advance of the belt and the peripheral speed of the discs, hence the typical wear described. With the removal of all the return rollers, the belt has reached a normal longevity for this kind of application!



**Figure 1.1**: Metering conveyor with drive pulley at tail = return side belt stretched = belt sag is null = belt pressure on roller nearly nil.



**Figure 1.2**: each disc digs a rut in the belt cover (belt/disk speeds ≠).

Satisfied by this first realization, still in 1986, the customer entrusted me with the maintenance of a conveyor of 120 m of along with whose belt was changed several times a year, because of several offsets and intense friction against the frame. I removed all the self-centering idlers (they were mounted upside down!?), And I arranged the return rollers in excess for a spacing of 6 m for the straight sections and a spacing of 12 to 18 m for the section "concave curve". The 12 to 18 m pitch of the concave section was obvious, by simply observing the "non-contact" (**fig.2**) of the belt on the rollers with the original spacing of 3 m.



**Figure 2.1**: in the concave curve the belt does not touch the roller with a usual spacing of 3 m



**Figure 2.2**: in the same concave curve, the belt touches the roller with a conforming spacing of 18 mm

In 1987, the same customer entrusted me with the rehabilitation of conveyor of the quarry link, about of 400 m along, with au drive pulley at tail, that is to say a belt "tense", return side. During work preparation, the factory ordered an insufficient number of return rollers of a specific model (base: old standard). During the erection of the new rollers on the conveyor, according to the original spacing of 2.5 m, instead of the theoretical 3 m considered during the preparation, we find that there was a lack of rollers. Given the delay in replenishing the missing rollers, I proposed to erect the rollers in a sequence of "one out of two" over the entire along of the conveyor, a spacing of [2.5 \* 2] = 5 m and thus finish the work in the allotted time.

**From these first montages, with a double spacing of the original value, I noticed:**

**•** a greater belt stability and reliability over time.

• an ease of adjusting the rollers during "**on-the-fly**" setting(method at that time).

#### STRATEGY

Based on its first experiences, I looked for the recommendations from the standards, with the aim of guaranteeing the stability of trajectory of the return strand, **without using complementary devices**, like the belt-training idlers.

It was a question of establishing the correspondence between the physical laws and their mechanical applications in the field of the conveyor. This approach qualified the "long spacing" between idlers.

#### ANALYSIS OF ISO STANDARD 5048 # 5.3.3

#### Applications with a ‘’long spacing’’

**Idlers, return side**

The calculations, confirmed by experience, show that, statistically, the ideal spacing between idlers of the return side is 12 to 15 m(2), if one complies with the requirements of article 5.3.3 (**fig.3** ). This distance can be 18 to 24 m(2) in the concave curves. In the case of short conveyors, this spacing, return side, is easily 30 m, i.e. there is zero roller on this length, depending on the weight of the belt and its breaking strength.



**Figure 3**: max sag = 2% of spacing = [2.3°\*2] = 4.6° of arc

**Idlers, carrying side, regular design section**

On the same ISO basis, the calculations show that the spacing between idlers of regular design section(3), carrier strand, can vary from 0.5 to 6.0 m, or more.

Note: a small spacing (**fig.4.2**) of 0.2 to 0.5 m can be recommended in the concave curves of large downward conveyors, to limit the belt festooning (collapse) between idlers (**fig.4.1**) when braking phase.



**Figure 4.1**: when braking, the belt festooning between the idlers, with a standard spacing.



**Figure 4.2**: when braking, the belt does not festooning between the idlers, with a small spacing.

This variation of "spacing" (0.5 to 6.0 m), on the same conveyor, is easily understood in the case of an overall ascending profile, with a concave curve at the end of the 1st section and a high elevation for the following sections. In fact, to obtain a "**short" concave curve radius** (**fig. 5**), it is necessary to have a low pre-tension in the belt, before the curve, hence the need for a short spacing between the idlers, of this section, for meet the requirements of Article 5.3.3. Conversely, when considering the sections at the head of the conveyor, with a high elevation, the tenseness in the belt increase considerably and the calculations show that a spacing of 6 m is perfectly consistent in terms of belt sag, to the maximum prescribed limit of 2% of the spacing between idlers, belt at full load.



**Figure 5**: Spacing variable between supports (S à XXL).

**Inverse principle**: "**short spacing**", **carrying side**

If this article advocates designs with a long spacing in the general case, **there are two special cases for which a short spacing is recommended**, except for the variable spacing described previously and the spacing of the idlers of convex curve which is calculated in angular value (**fig.6.1**), as a function of the maximum permissible stress in the belt edges.



**Figure 6.1**: convex curve: spacing in angular value.



**Figure 6.2**: Straight section: spacing in linear value.

**Spacing reduced** between idlers, compared to with time

1. **Section under the feed, fall zone**:

Here, the calculation must take into account, in addition to the normal load(4) of the product on the belt:

* + the load from the product column (**fig.7**) in support of the feed. This depends on the section of the trough, delimited at the level of the belt and extended upwards according to the vertical projection of this section ;
	+ the impact energy resulting from the fall of the product from the equipment upstream.

These are two distinct values that must be considered the most restrictive.



**Figure 7**: Idler spacing, feed section

S: shot ; M: average ; L: long.

Here, it is a question of limiting the belt sag (**fig.3**) between two idlers of this section, so as not to generate:

* of product loss (lateral leakage)
* an excessive strength to the belt movement, by an excessive belt sag (**fig.8**).



**Figure 8**: Sag between supports excessive = Strong strength important ... until infinity!

Of a usual pitch of 300 mm, the calculation often recommends a pitch of 200 mm, see 150 mm. Thus, the subject is perfectly mastered for a low cost. This design is true for the extractors and even more true to right of the drain door of the same extractors. The lack of calculation on this point is at the origin of the sliding supports in the feeding sections; which is a progress in general, but a source of disorder in some cases.

1. **Dual direction belt**:

In the case of a belt with a **single way**, the rollers of the supports have the 2nd function of "guiding" the belt. For this, it requires a maximum radial force of belt on the roller, but within the limit of a belt deflection according to Article 5.3.3 and consistent with the product handled.

On the other hand, for **a two-way belt**, it is necessary to aim for the smallest possible effect of direction by the rollers in general and the side rollers in particular (trough support); therefore, replacing the side rollers with sliding pads is an advantage when possible. For the same pre-tension of the belt and the same product load, by reducing the spacing between the rollers, the radial force of the belt on the rollers is reduced as well as the directional effect of the side rollers. Here, one seeks a "neutral" direction applied by the rollers to the belt, whatever the direction of belt movement and which is not influenced by the manufacturing uncertainties of the brackets (usual tolerance of manufacture) and their adjustment on the conveyor..

Note : for a two-way belt.

* In addition to the design with a reduced spacing between idlers, carrying side, it is appropriate to apply to the belt a pre-tension of the order of 4% of its breaking strength; for this, it must be ensured that all the components of the conveyor can withstand this constraint, in particular the pulleys (ferrule, shaft, bearings, bearing-housings).
* Brackets with "pinch" are not compliant for this application.

The **longest spacing between idlers**, currentlyin service since 2007, is **36 m**, for **300-350 mm of sag** (fig.3). The idlers support the belt, bottom side, which is a stretched strand, between the head pulley and the drive pulley, 216 m further, on return side. On this same 5 km conveyor, the **idler spacing of carrying side is 6 m** near the head. Since the change of spacing, the disorders have disappeared and I received congratulations from the director of the plant.

Many short conveyors, up to about 30 m center distance, upgraded by me, have **zero idler on bottom side** (**fig.9**).



**Figure 9**: Bottom side = zero idler ! It’s great !

All new conveyors, repaired or upgraded with the support of C3 Expert, have benefited for 30 years from a **spacing of 12 to 15 m, bottom side**, whatever the industry and the geographical zone in the world.

#### COMPARATIVE ANALYSIS

Comparing a "**short**" (usual) spacing between idlers of the bottom side of a conveyor, i.e. 2.5 to 3.0 m according to the example ISO 5048 # 5.3 of 1973, with the automobile world, this would correspond to an over-inflated car tire with 15 bar (usual pressure 2.5). In this case, the tire contact on the road is a "point" instead of a surface and the handling of the car becomes particularly fragile. From this comparison, we can assume that a short spacing between idlers does not guarantee a good belt trajectory.

The apparently centered trajectory of a belt, supported at a **short spacing** between idlers (3 m), is always "**random & precarious** (5)" and a source of disorder.

#### HISTORICAL SOURCE

Until the 1970s, the belts with cotton carcass were heavy compared to them strength and the examples in ISO 5048 of 1973 were coherent with an arrow limit of 0.5% to 2.0% of spacing between idlers. These values came from tests.

In the September 1989 version, the 2 examples it’s removed which indicated a pitch of 1.0 to 1.5 m for the carrying side idlers and 2.5 to 3.0 m for the bottom side idlers. It can be deduced that the standardization commissions had realized that the examples of 1973 no longer corresponded to the recommended limits of sags (0.5% to 2.0% of spacing), because of the evolution of the belts, especially with polyester carcass

#### TECHNICAL BASIS

**What are the technical criteria that make a belt sag less than 0.5% or greater than 2.0% of idler spacing give a problem?**

Deflection less than 0.5% of idler spacing

This technical point concerns only roller supports. All models of "slippery" supports are excluded by nature; as well as the idlers of convex curved sections and two-way belts governed by other rules.

Here, it is the function of "direction" of the rollers, applied to the belt, which must be considered. When the belt sag between two idlers tends to zero, the "steering" function of the rollers tends to disappear (**fig.10**). as previously described with the over-inflated tires of a car. In this case, it is the real forces in the belt, in the observation zone, which give the direction (trajectory) to the belt. Of course, everyone thinks of the misalignment of the product on the belt to cause its offset; this offset will be a maximum of ½ of the decentering value in mass and in millimeters of the product on the belt, because it is necessary to take into account the forces of pre-tension and traction applied to the belt.

To illustrate the belt forces internal, it is sufficient to observe a belt, running empty, in a concave curve and affected by asymmetric forces at the conveyor axis, with little or no belt contact on the roller, in the curve. The observation shows that the belt have a laterally moves without being influenced by the rollers because there is no contact.



**Figure 10**: if Pb tends toward to 0, the directional effect of the rollers "dir" tends toward to 0 because the roller force Fr tends toward to 0.

Attention, the angle x° is accentuated to be visible.

With a wealth of this observation, it remains only to identify the origin of the "asymmetric" force or forces that influence the belt trajectory. Either it is a defect in the belt during its manufacture, its implementation, its exploitation and / or it is, often, a geometric position defect of at least one pulley.

Note : in some cases, this asymmetry of forces in the band can be corrected(6) ... but especially not with self-training idlers!

Deflection greater than 2.0% of idler spacing

This technical point concerns first the return idlers.

If we take again the example of the tire of the car, but correctly inflated with 2.5 bar, its contact on the road corresponds to a "surface" of very precise dimensions and defined by the manufacturer. By transposing this example to the conveyors, it is easy to deduce that **the belt contact on the rollers must correspond to a surface and not to a line or to one or two points** (the 2 edges of the belt). Thus, a belt deflection of 2% of the idler spacing corresponds to a winding arc on the roller of 4.6°; that is to say an area of: [roller Ø \* / 360 ° \* 4.6 ° \* belt width].

With this first criterion of contact surface, one must also consider the factor "**belt longitudinal stiffness**(7)", to obtain a centered and perennial belt trajectory. The longer the idler spacing, the longer the belt longitudinal stiffness decreases.

It is the combination of the maximum permitted "winding arc" factors (see maximum sag 2%) and "idler spacing" the longest possible that make the belt trajectory quality.

So, why not recommend belt sag greater than 2% of the idler spacing?

Because:

1. The belt trajectory quality is not improved because other negative factors are involved.
2. The forces resistant to the belt running, therefore the power absorbed by the pressing of the belt on the rollers, increase exponentially (**fig. 8**), in particular carrying side, beyond 2% of the deflection of idler spacing. The mathematical model used does not support this condition.

#### AVANTAGES & DISADVANTAGES

**The long idler spacing’s are in perfect conformity with:**

**\* Directive 2006/42/EC**

**\* The safety standard EN ISO 12100, articles 4 and 6.**

*For the record, the EN 620 standard (conveyor safety) is normally applied after the requirements of EN ISO 12100 have been exhausted.*

**\* Technical standard ISO 5048, article 5, of1987**

**Bottom side**

Short conveyor, length **up to about** 30 m

Either « **zero** » return idler!

**Advantages**

* No trapping hazard and no hazard for ejecting rollers;
	+ a very high level of safety for zero cost.
* Clean floor under the conveyor
	+ A hazard of falling (slipping) removed;
* No maintenance charge;
* No risk for bad belt trajectory due to clogged rollers, poorly adjusted;
* Amortization of jolts at start-up;
* Measurement of the continuous tension of belt;
* Reduced overall cost on this item;;

**Disadvantages**

* In some cases of existing conveyor, it is necessary to move the cross struts of the frame to let the passage of the belt
	+ The belt sag can be reduced by applying a large pre-tension; in this case it is necessary to make sure of the good choice of the belt and the pulleys (shaft, bearings, ...).
* No other inconvenience.

Long conveyor, center distance greater than **30 m**

The idler spacing is:

Belt with soft strand: **12 à 15 m**.

Belt with soft strand, concave curve : **18 à 24 m**

Belt with stretched strand: **36 m** and more.

**Advantages**

* Reduction in proportion to the trapping hazards of and hazard by roller ejection.
	+ Either a reduction of the cost of the protective devices to these two hazards.
* Great stability of belt trajectory and durable in time;
	+ a high level of safety as a result;
	+ Either the removal of all the self-trainer idlers!
* Easy and quick adjustment of rollers, conveyor "off, safe";
* High adjustment accuracy (≈90 ° +/- 0.05 °);
	+ the belt becomes the measuring instrument(8) for adjusting the rollers.
* Precise continuous measurement(9) of the belt tension in location T2 and T3
	+ this measure is decisive, especially for strategic conveyors;
	+ conversely, the measurement of belt tension, with a usual spacing of 3 m, of 6 m, is affected by a major uncertainty which makes the measurement unusable.
* Long life of rollers(10);
* Major amortization of jolts in transient phases and in operation;
	+ The "long spacing" is much more effective than counterweight pre-tensioning systems to limit load surges on the belt.
* Elimination of clogging of standard rollers (steel) or rollers coated 35 Shore rubber;
	+ this design:
		- eliminates the auxiliary conveyor called "crumb tray" placed under the head section of the main conveyor.
		- renders the belt-turning systems useless; The belt is wrung out at the passage of first rollers.
* Reduced purchase cost, including high quality rollers;
	+ a conveyor frame of type caisson, with a suitable profile, allows for a span, between two feet, of 12 m to 15 m, which reduces civil engineering.
* Reduction of energy consumption;
* Low maintenance costs.

**Disadvantages**

* Sensitivity to crosswinds
	+ In the case where the frame design does not provide side wind protection, a wind net or other device must be added.
* In new works, this disadvantage does not exist insofar as the frame design incorporates a "windshield" profile.
* In the case of existing rollers of the "anti-clogging rubber ring" type, they must be replaced by standard rollers (ring-free ferrule), bare or coated 35 Shore rubber.
* Adjustment training, conveyor belt to standstill, safe, is highly recommended.
	+ C3 Expert is at the origin of a simple method, accessible to all, very effective.

**Carrying side**

All conveyors

Of which the idler spacing is: greater than the usual **1.0 m** to **1.50 m**.

**Advantages**

* Guarantees the steering effect of rollers on the belt;
	+ trough idlers with "pinch(11)" angle are no longer needed
* Reduces energy consumption, by reducing the number of rollers and the pinch angle of the usual idlers.
* Reduces the cost of protection devices against the trapping hazard.

**Disadvantages**

* Without any significant inconvenience, apart from having to calculate the conveyor and the idler spacing; what is the minimum expected of a manufacturer; this which is, also, within the scope of maintenance department.

#### CONCLUSION

The balance between advantages and disadvantages largely demonstrates that the design of the conveyors, using a "long idler spacing" constitutes a benefit without equivalent. It's up to you to make this design, more than 30 years old, the rule now usual.

#### YOUR QUESTIONS

Because this technology of "long idler spacing" can question you, intrigue you, then, ask your questions on our forum : <http://www.c3-expert.fr/>.

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**(1) Long spacing**: C3 Expert considers that the distance between 2 idlers is "long spacing" when it is at least 3 times greater than the usual spacing, as given in the examples of the ISO 5048 standard, # 5.3.3, version 1973; either the values ​​of 1.0 to 1.5 m, carrying side and 2.5 to 3.0 m for bottom side. Attention, these examples were removed in the 1989 version. In my first applications, in 1986, I attributed the qualifier "long spacing" to distances between idlers of 5 to 6 m, before considering that this qualifier did not apply not for these lengths..

 **(2) 12 to 15 m, 18 to 24 m**: it is a multiple of the usual spacing of 3 m, but this spacing can be a "non-multiple" value and of the same order of magnitude..

**(3) Regular design section**: This refers to all sections of the conveyor after the end of the feed chute and to the jetty pulley.

(4) **Normal load of product**: here, it is the mass of product, per meter, at the peak flow (basis of calculation), found on the regular design sections, carrying side.

(5) **Precarious and random Trajectory**: A belt trajectory is precarious because it takes a small variation of one factor for the belt to drift and the trajectory is random because we do not know when the drift will occur.

(6) **Method for correcting the belt asymmetric forces**: refer to my articles "Mastery belt trajectory belt \_ prerequisites / Settings".

(7) L**ongitudinal belt rigidity**: this criterion can be likened to the stiffness of a wood board, seen in the transverse direction. When the rollers are poorly adjusted, the belt is **shifted off**; when this longitudinal rigidity decreases, the belt rotates in the same roller direction.

(8) **The belt becomes the measuring instrument**: irrespective of its intrinsic quality, the belt is used as a precision measuring instrument, knowing that the amplitude of belt offset is proportional to the number of meters of belt passing on the roller in observation (see articles «Mastery belt trajectory\_ prerequisites / Settings»)

(9) **Accurate continuous measurement of belt tension**: Since 2002, C3 Expert has developed a method of continuously measuring belt tension, with very little uncertainty, using an ultrasonic sensor.

(10) **Long life of rollers**: in the case of the usual 3 m bottom side, the load applied to them by the belt is 5% to 20% of their admissible load and yet they perish too quickly; on the contrary, the rollers, arranged in a long spacing with a applied load of 100%, have a considerably longer life.

(11) **Pinch angle of trough idlers**: this angle meets the ISO 1537 standard. In this case the side rollers of trough idler have a force convergent to the conveyor axis. It's supposed to re-centering the belt in case of drift. This angle represents a considerable power absorbed on the long conveyors, for a very relative efficiency.

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