

# Design Manual



universal **ELEVATOR**



A Gentle and Flexible Solution

## **Introduction**

This document describes the issues that have to be taken into account at project planning of bucket elevators from Simatek Bulk Systems A/S (Simatek). This document covers the E type elevators from size 33E to size 460E.

## **Product description**

The bucket elevator is designed for gentle conveying of bulk materials.

The product remains in the same bucket from the filling to the emptying station so that the product is not exposed to any mechanical influence, and hence the product will not change neither form, volume nor weight.

Through the entire elevator 2 chains run parallel to each other, in which a continuous bucket row has been suspended.

When a bucket passes under an inlet, it will be filled with the product and it will remain in the bucket until it is emptied in an outlet.

The elevator is always equipped with an end outlet, and can be delivered with one or more intermediate outlets.

At the end outlet the buckets will always, with no exception, be emptied, ensuring that the buckets are empty when returning to the inlet.

The buckets' moving pattern is controlled by a row of guide rails, leaving the buckets fixed during filling and then turning them during emptying. Because of the buckets overlap it is necessary to switch overlap during operation. For buckets with no overlap there will be fewer guides in the elevator. Buckets with no overlap can only be used together with a drum feeder ensuring separate feeding into the buckets.

## **Content of delivery**

### **Basic supply**

- Bucket elevator, with open in- and outlet.
- Automatic, pneumatic chain tensioner.
- Overload protection, type HPL, incl. softstarter.

### **Options**

#### **For elevator:**

- Automatic chain lubrication system with a pumping station and a compressed air cleaning unit
- Intermediate outlet
- Intermediate outlet, with pneumatic or electrical actuator

### **Feeding systems**

- Drum feeder with local control box
- Vibrating feeder with vibrator motor

### **Electrical and automatic**

- Rotation guard
- Frequency converter with overload protection
- Overload protection, type APM (by custom supplied frequency converter)

### **Not included in supply**

- Outlet hopper
- Electrical control unit for the elevator
- Motor protections, fuses, contactors etc.
- Local control boxes for service (hold-to-run principle)
- Platforms and access ways
- Support construction

## **Premises**

### **Operating mode**

The elevator has to run in automatic mode.  
The control unit has to be connected and set with all mentioned sensors.

### **Feeding of the elevator**

 Product supply to the inlet has to be conducted via a flexible connection.

The bucket elevator is designed to a specific product type and maximum capacity, which must not be exceeded.

The filling degree of the buckets depends on the product and feeding system.

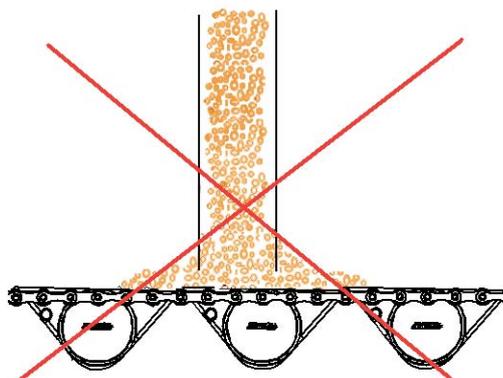
The best filling of the buckets is achieved when the product feeding is in a continuous and controlled flow, as the elevator itself cannot distribute the product in the buckets.

The feeding systems from Simatek are designed for controlled feeding of the buckets.

If other feeding systems are used, the following must be observed:

To achieve gentle, continuous conveying, the falling height should be as low as possible, and in the same direction as the buckets motion direction, if possible. The falling height should not exceed 400 mm, measured from the bottom of the buckets.

Summarized, the buckets must not be overfilled (according to the pre-set filling degree) so that it may prevent the buckets to convey freely, e.g. the product must not "stand" on the buckets, so that buckets must be pulled through the product.



### Filling of buckets

It is important that the product is distributed evenly in the full bucket length (opposite to fig. 1 C). Due to spillage and operation safety it is also important that the product is placed evenly in the bucket (opposite to fig. 1B). The latter is possible by ensuring that the product flow runs with the bucket moving direction. See fig. 1 A for correct product distribution.

For optimum distribution use drum feeder, a product dispenser, or a vibrating feeder especially designed for the elevators. If these are not included in your supply, the distribution is to be controlled otherwise.

If a vibrator adds the product (invalid for vibrators from Simatek), it must be placed perpendicularly to the bucket moving direction. The vibrator end must be cut off diagonally, see fig. 2, to ensure a product distribution in the entire bucket length. Belt conveyors can be placed diagonally after the same principle.



Fig 1. Difference between correct and wrong bucket filling.

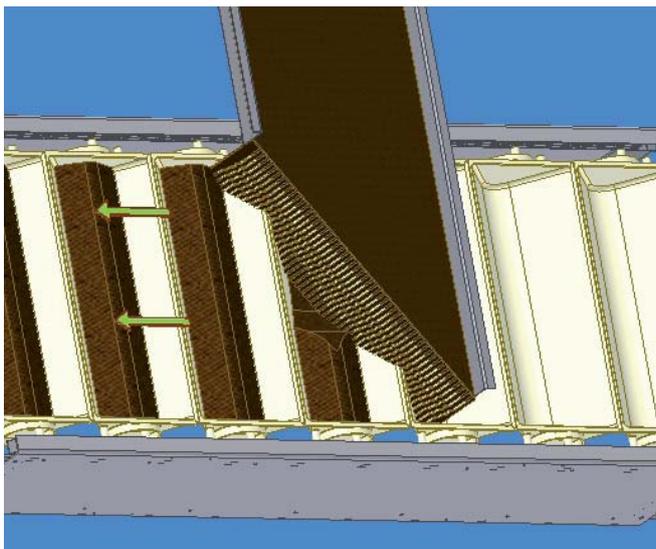


Fig 2. Feeding the elevator with diagonally cut vibrator placed perpendicularly on the transport direction, seen from above.

### Start / stop of feeding equipment

Product feeding must be stopped (possibly by means of a damper) before the elevator is stopped. Equipment such as drum feeder, product dispenser, vibrators, belts etc. must be stopped before the elevator is stopped. A suitable after-running must be carried out to avoid overfilling of the "last" buckets before stop.

Thus, the elevator must also be started and ready for operation before the feeding system is started.

### Dust:

Certain products develop dust during the filling and emptying of the elevator. If the dust is not removed, this may cause problems with deposition on chains, buckets, and guides with the risk of wear as a consequence.

Simatek's feeding systems are provided with an aspiration branch which must be used when conveying dusty products.

Additionally, it may be necessary to establish aspiration branches on equipment associated with the other elevator sections (e.g. the outlet hoppers). These branches are not part of the delivery.

Generally speaking, the aspiration branches have to be placed so that dust is sucked away from the elevator components, i.e. place the aspiration branch in the top end of the outlet hopper, rather than in the elevator section above the outlet hopper.

### Drum feeder



Product supply to the inlet has to be conducted via a flexible connection.

A service damper (not part of the delivery) must be mounted on the inlet side of the drum feeder.

The drum feeder is a unit ensuring optimal filling of the buckets. The internal distributor is designed with a free passage. This open drum is only meant for distributing the product; it has no shut-off function.

The drum feeder inlet should always be filled; otherwise, the product will fall through the distributor during filling with such high speed that it causes product waste outside the buckets.

Therefore, it is important that the drum feeder is mounted in a way ensuring sufficient buffer amount on the inlet side of the drum feeder.

Note that the required buffer amount may be contained in the downpipe in front of the drum feeder.

When the product flow is not sufficient, the internal damper will close. The damper will open once there is sufficient product flow in the inlet of the drum feeder. Opening and closing of the damper is controlled by the level sensor placed in the inlet of the drum feeder.

The damper contains an electric actuator enabling stepless setting of the opening angle to achieve a correct flow through the distributor.

The internal damper controlled either by a PLC-control or an analogue control.

The control is mounted in the controlling box on the drum feeder.

When stopping the elevator the service damper must be closed. Remember the necessary after-running to ensure emptying of the drum feeder while the elevator is still running.

The service damper and the buffer bin are not part of the standard delivery of the drum feeder.

**Vibrating feeder**

Product supply to the inlet has to be conducted via a flexible connection.

A service damper (not part of the delivery) should be mounted on the inlet side of the vibrating feeder.

The vibrating feeder is a unit for traditional filling of the buckets, and provides a continuous filling; however with limited filling degree.

Control of flow and distribution is done by adjusting the flyweights in the vibrator motor, by adjusting the opening of the manual damper, and eventually by adjusting the frequency (if installed) on the vibrator motor. A frequency converter is not included in supply.

The vibrating feeder should only be used where the feeding is continuous and with a constant amount of product in the vibrator. Small amounts of product will not be stopped by an empty vibrator, but will end up in the buckets in an uncontrolled flow; hence with spillage of the product.

When stopping the elevator the service damper should be closed. Remember the necessary after run to ensure emptying of the vibrating feeder while the elevator is still running.

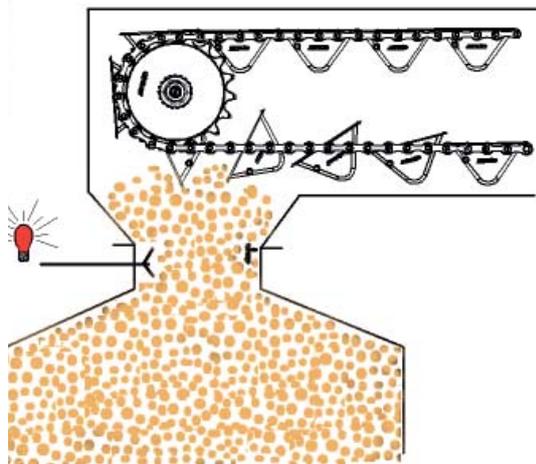
## Outlet

The basic elevator is equipped with an end outlet. As an option, the elevator can be configured with one or more intermediate outlets. Emptying of buckets at intermediate outlets activated el-pneumatic.

Regardless the outlet type, it is required that the outlet does not overflow, as this will prevent the bucket to empty as intended.

A level switch after each outlet is therefore required (level switches are not included in supply).

The level switch should be placed in the top end of the outlet hopper/downpipe taking into account the product flow and the necessary after run.



### Mounting and fastening

The elevator is designed for indoor use. If the elevator is placed outdoor, another construction must be established to protect the elevator against weather.

The bucket elevator is delivered in the following assembled sections:

Drive section, tension section, and corner sections.

Intermediate sections are delivered as preassembled side plates, coverings and connecting consoles.

The coverings (only 33E - 200E) act as a part of the stiffening of the elevator construction.

When designing support for the elevator, maximum load (incl. overfilled buckets) should be taken into consideration (catastrophic weight).

Please note that support of upper corner section should sustain load of chains, buckets, and product load of product for the full vertical height.

During mounting it should be ensured that sections are securely levelled vertically and horizontally. Distance between supports should not be more than 4 m for vertical and upper horizontal part.

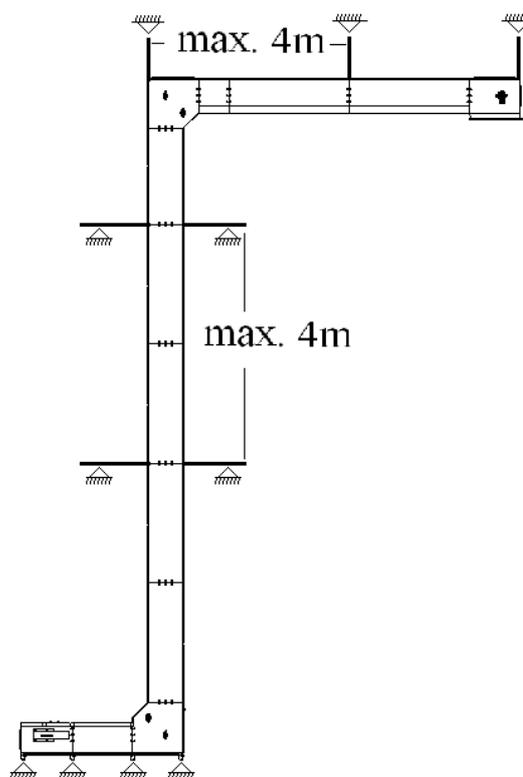
Supports on the vertical section:

- Type 33E - 200E: The support should support the vertical section up to the next support.
- Type 460E: The vertical section is self-supporting up to 15 m, the load is supported by lower corner. There must be supports for each 4m, restricting horizontal deflection of the section.

Supports should be fastened to the flange where sections are assembled (support are not included in the delivery). If the supports cannot be fastened to the flanges, the supports should be designed so that they compensate for the off set.

Please note that support must only be fastened to the permanent side plates (only 33E - 200E) and never to the loose coverings.

The lower horizontal sections are equipped with base consoles, which should be fastened to the base/construction below.



## **Connection points**

### **Mechanical**

Supports: Please refer to the section "Mounting and fastening".

#### **In- and outlet**

The in- and outlet are equipped with a flange for the mounting of a feeding system and/or a flexible connection.

Simatek's feeding systems are designed for direct installation on the elevator and require no further support.

Other feeding systems may not be supported on the elevator.

 Product supply to the inlet has to be conducted via a flexible connection.

If a feeding system from Simatek Bulk Systems A/S is used, the requirement of flexible connection is related to the inlet to the feeding system.

Load from the silo content must not be placed directly on the elevator or the feeding system, unless necessary load alleviation is established.

### **Pneumatic connections**

#### **Compressed air quality:**

Particle size: Max 5 µm.

The pressure dew point must be at least 15°C under ambient and medium temperature.

However, the pressure dewpoint may not exceed 3°C.

Oil content: Max 5 mg/m<sup>3</sup>

	<b>Option</b>	<b>Documentation</b>
Chain tensioner, supply 5-6 bar. Consumption: None		D2
Chain lubrication system type 1, supply 5-6 bar with or without air cleaner	X	D3
Intermediate outlet, with pneumatic actuator, 5/2 valve, supply 5-6 bar. Consumption: 0,1 NL per stroke per cylinder	X	D5+E5

Chain lubrication system type 2 does not require compressed air.

**Electrical and automatic connections**

	Option	Documen- tation
Elevator, motor, brand: SEW.		SEW std. dokumenta- tion
Elevator, Overload protection, type HPL, incl. soft starter. Protection class: IP20 for installation in board		E1
Elevator, Simatek frequency converter, Unidrive M400. With built-in overload protection. Protection class: IP20 for installation in board.	X	E1
Elevator, Overload protection type APM. For frequency converter delivered by customer. The frequency converter <b>must</b> be set for Open Loop control. Protection class: IP20 for installation in main board. Note! The APM module must not be installed close to the frequency converter	X	E1
<b>Chain tensioner</b> 1 pc. pressure switch 24V DC. Low pressure must stop the elevator. 1 pcs. inductive sensor (NC) 24V DC. Signal must give warning for chain tensioner in outer position, i.e. chain must be shortened		D2
Rotation guard, 24V DC	X	E7
<b>Chain lubrication system</b> <b>Type 1)</b> Air compressed lubrication with/without air cleaning. Start / stop 1*24V DC Low level in oil container: 1*24V DC Air cleaning: Valve not included.  <b>Type 2)</b> Basic lubrication. Only manual operation and surveillance, no signals	X	D3
<b>Intermediate outlet</b> Pneumatic 5/2 valve. Open/close signals: 2 separate coils 24V DC End stop: Reed contact (NO) 24V DC  <b>Type 33E to 200E, per intermediate outlet:</b> 1 pcs. pneumatic valve 1 pcs. pneumatic cylinder 2 pcs. Reed contacts  <b>Type 200E-FRB and 460E-FRB, per intermediate outlet:</b> 2 pcs. pneumatic valve 2 pcs. pneumatic cylinder 4 pcs. Reed contacts	X	E5

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## Electrical and automatic connections

	Option	Documentation
<p><b>Drum feeder with analogue or PLC control</b> Local control and level sensor is included. Wiring from the control to the level sensor must be done during installation. (Approx. 1 m wire to the level sensor is included). The control box must be mounted on the console on the drum feeder.</p> <p><b>Drum feeder with analogue control</b> Supply: 1*230V, 50Hz.</p> <p>Digital signals 24V DC: Operational signal from elevator: 1*DI Forced opening of damper (emptying of feeding system): 1*DI</p> <p><b>Drum feeder with PLC control</b> Supply: 1*100-240V, 50 / 60Hz.</p> <p>Digital signals 24V DC: Operational signal from elevator: 1*DI Forced opening of damper (emptying of feeding system): 1*DI Recipe select: 3*DI</p> <p>For remote control: Remote control from PC via the Web-gate programme: Ethernet</p> <p><b>Drum feeder for customer delivered control</b> Level sensor and controller for the electrical actuator is included. Max. cable length between controller and electrical actuator: 3m. The level sensor is delivered with 2m cable. Other cabling is not included.</p>	X	E12
Vibrating feeder, supply 3*400V AC	X	E4

**Electrical connections on external equipment****Elevator**

- Level sensor at each outlet

**Feeding system**

- Limit switches on service damper before feeding system (if the damper is supplied with limit switches)

**Vibrating feeder**

- Level switch before inlet to feeder, to control start / stop of vibrator (only by non-continuous feeding)

**Control Units and automation**

In the following please find a description for conditions applicable for control of the elevator and for the design of automation in this relation.

**Start/stop**

Starting and stopping of the elevator and integration with the rest of the equipment must be done with consideration of the necessary time for the afterrun of the empty equipment. Moreover, we draw your attention to the positioning of level sensors at outlets and to the time needed for the empty running of the elevator.

**Overload protection HPL**

The overload protection HPL and the soft starter must be connected as shown in the Mounting Instructions. If the elevator is stopped due to overload, the causes must be identified and fixed before reset and restart. If correctly installed, the HPL will make sure to stop the elevator when overloaded in order to protect buckets and guides.

**Frequency converter with built-in overload protector**

The frequency converter must be connected as shown in the Mounting Instructions. Please pay attention to the signals from the chain tensioner and the level sensors.

If the elevator stops due to overload, the precautions applicable to the HPL will also apply here.

Please note max. chain speed:

Type 33-200E: 21m/min, with drum feeder the recommended max. is 16m/min.

**Overload protection APM**

When using a frequency converter, not delivered by Simatek Bulk Systems A/S, the APM unit must be used and connected as shown in the Mounting Instructions.

If the elevator stops due to overload, the precautions applicable to the HPL will also apply here.

Please note that the APM monitors the engine power consumption. Therefore, the APM is not active when the rotational speed is adjusted by the frequency converter.

The frequency converter must be used for operating the elevator with a fixed preset chain speed. Therefore the frequency converter must be in Open Loop Mode (Open Loop control). This may lead to a minor variation between the set point and the actual rotational speed, however this is considered of no significant importance.



The frequency converter **must** be set for Open Loop control.

Please note max. chain speed:

Type 33-200E: 21m/min, with drum feeder the recommended max. is 16m/min.

**Automatic chain tension adjuster**

2 air cylinders ensure that the chains always have the correct tension by moving the shaft in the tension section. The system is in operation when pressurized.

There is a pressure switch giving alarm for low pressure. And must stop the elevator as there is a risk of break-down when operating with too low pressure on the chain tensioner. The automatic chain tensioner has 1 pcs. inductive sensor, which will signal if the chain needs to be shortened (i.e. the cylinder is close to max. position).

**Outlet and intermediate outlet / level sensor**

The intermediate outlet must only be operated when the elevator is in operation, whether or not the buckets are containing product (i.e. the buckets must be in motion).

To avoid waste and uncontrolled emptying of the buckets, the intermediate outlet must be activated before the filled buckets enters the tipping point (i.e. with empty buckets and the elevator in operation).

If switching randomly between outlets during operation are required, the feeding of the elevator must be stopped equivalent to min. 10-20 buckets passing (20-40 seconds).

Activation of the outlet in question must then be done whilst the empty buckets are passing.

The time from the empty buckets are passing the inlet to the specific intermediate outlet can be calculated from the actual chain speed and the geometric measures on the elevator and they should be adjusted at start-up.

Deactivating an intermediate outlet is possible regardless of the elevator being in motion or not.

Open and closed signals respectively: 2 separate coils 24V DC. The cylinder has end stop switch type Reed switch (NO) for open/closed position.

## Feeding systems

### Drum feeder

The local control unit must have constant power supply.

Please see further info regarding digital signals under "Electrical connections":

Description of the function of the local control unit (for orientation):

When the level sensor records product in the inlet the count down will start on timer T1. When time is up the feeder damper will open.

The timer, T1, must ensure sufficient product amount in the feeder inlet.

Adjustment of the feeder damper is done using the potentiometer in front of the control unit.

When the inlet is empty (level sensor goes low), the timer T2 is activated. When the time is up, the damper is closed. The time in T2 must ensure that the feeding system is run empty, typically 1-5 seconds).

### Vibrator feeder

The vibrator feeder must be started and stopped by start / stop on the vibrator motor.

The vibrator must be stopped and any service damper must be closed before stopping the elevator.

Beware of any afterrun for empty running of elevator.

When operating with a frequency converter please beware of any requirements to frequency area, acceleration time and frequency jump cf. the vibrator feeder instructions.

## **Start up**

### **Before start up**

#### **Backstop**

The drive shaft is equipped with a back stop. Please note that the elevator must not run reverse, not even for control of direction of rotation. (May be built into the motor for large motor sizes)

#### **Chains**

All chains come in pairs and must be mounted in pairs. As these chains are pulled by pairs, they must be mounted parallel opposite to each other in the elevator.

Instructions regarding Unpacking and Storage should be followed carefully. Not relevant for type 460E

#### **Guides**

The buckets' moving pattern is controlled by a row of guide rails, which e.g. fix the buckets during filling and turn them during emptying.

These guides are not adjusted at delivery, and thus they must be adjusted before start-up, see the Mounting and Operation Instructions.

### **Adjustment**

#### **Line-up**

Before start up it must be ensured that the line up of buckets are correct, see the Mounting and Operation Instructions. If not, the buckets and guides will be damaged.

#### **Overload protection**

Regardless the choice of overload protection, the instructions regarding test should be observed and followed, and tests must be done both with empty buckets and with filled buckets.

#### **HPL Overload protection**

The elevator is delivered with an electronic device (HPL), which constantly monitors the power consumption of the motor. The device should be adjusted to the exact configuration and parameters. Thus, the data cannot be entered until the data of normal operation are known.

After correct set-up of the device any short or long term overload will be monitored and will result in immediate stop of the elevator in order for destructions to be avoided.

The HPL unit will not function with frequency converter operation.

#### **Frequency converter with an integrated overload fuse**

As an alternative, the elevator can be delivered with a frequency converter, having the same functionality as the HPL and the soft starter. The converter also includes a module for logging of power consumption as well of external inputs such as chain tensioner and level sensor.

#### **APM Overload protection**

If the frequency converter is not supplied by Simatek, the elevator must be supplied with an overload protection type APM, having the same functionality as the HPL unit.

Please note the special requirements for frequency converter operation and installation as mentioned in "Control units and automation".

## **Construction and standards**

Elevator and equipment designed according to good engineering practice.

The risk assessment is based on the requirements from the machinery directive.

Basically, DS/EN ISO 12100: 2011 (Type A standard), "Machinery safety - General principles for construction - Risk assessment and risk reduction" is used. Furthermore other relevant harmonized standards are used.

Specific for the elevator, EN 618:2002+A1:2010 (Type C standard), "Continuous handling equipment and systems - Safety and EMC requirements for equipment for mechanical handling of bulk materials except fixed belt conveyors" is used.

Relevant elements of EN 618 must be taken into account when designing and implementing the elevator and equipment in the final plant.

Attention is particularly drawn to the following issues: It is the responsibility of the end user to ensure that operation and service is done only by suitable trained personnel in operation and service of the elevator and equipment. This is particularly applicable regarding access to the elevator which must only take place when the elevator and the equipment has been stopped and secured.

Furthermore, it is the responsibility of the end user to ensure that the elevator and the equipment are kept in a good maintenance condition.

### **Declaration of conformity according to the Machinery Directive**

The following agreements are included in the delivery: Declaration of conformity according to Machinery directive 2006/42/EC appendix IIA

Electrical equipment conforms to the requirements in the following directives:

Low voltage directive 2014/35/EU

EMC directive 2014/30/EU

## **Implementation of the elevator by the end user**

### **Control of the elevator**

Control of the elevator is not part of the delivery. Design and implementation of the control system must be done according to:

- EN 618 paragraph 5.2 Electrical hazard
- EN 60204-1 Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- EN 1037:1995+A1:2008, Safety of machinery - Prevention of unexpected start-up

### **Demands to the customer / end user**

In the risk assessment according to Machinery directive 2006/42/EF the EN 618 is used.

However, please note that the Simatek bucket elevators cannot be compared to "Bucket Elevator" on all issues as defined in EN 618 paragraph 3.1.3, in that the Simatek bucket elevators are running significantly slower, and are executed as a closed construction.

Therefore, the risk assessment gives a safety level "on the safe side" compared to EN 618.

### **Local control**

For use during start up, adjustments and service it is required to install a local control box for activating the elevator according to the hold-to-run-principle (not included), according to EN 618, paragraph 5.12. Must be established by the drive section and the lower corner.



#### **Warning**

If the local control is not established, access to moving parts (e.g. chains and buckets) must only take place when the elevator is secured against unintended start.

Operation of the elevator, e.g. for control or adjustment of guides or lubrication of chains must only take place either with locked doors, or by rotating the cooling fan on the motor manually.

### **Electrical connection**

Electrical connection of the elevator and equipment must be carried out according to the applicable legislation on site.

**Simatek Bucket Elevator Modular Construction  
(Standard Model)**

**Upper Intermediate Section:**

Steel side plates with steel shieldings in top and bottom.

- Type 33E - 200E: Fixed bottom plate.
- Type 460E: Bottom with drawer. 2 m section length. Adapter lengths of 100 mm. Optional monitoring of intermediate outlet.

**Upper Corner:\***

Inspection door with key lock in the gable and in the top. Chain wheel with bearings. Steel shafts mounted with bearings.

**Drive Section:\***

Direct coupled helical-bevel gear. Backstop. Guide for emptying. Inspection door with key lock in the gable and in the top. (Type 460E: only inspection door in the gable)

**Vertical Intermediate Section:**

Steel sides in 2 m section length. Adapter lengths of 100 mm.

- Type 33E - 200E: With steel shieldings on front and backside.
- Type 460E: Inspection hatch per 2m (Optional).

**Lower Corner:\***

Inspection door with key lock in the gable. Cleanout drawer in the bottom. Chain wheels with bearings. Steel shafts mounted with bearings.

**Tension Section:\***

Steel shaft mounted between guide-way bearings. Automatic pneumatic chain tensioning. Chain wheels with bearings. Cleanout drawer in the bottom. Inspection door with key lock in the gable.

**Lower Intermediate Section:**

Covered inlet section with guides throughout the whole length. Cleanout drawer in the bottom. Bases between all lower section assemblies.

**Shielding:**

The elevator is delivered dustproof, intended for a weak underpressure.

\* Upper and lower corner sections plus tension- and drive section are delivered assembled. The rest of the sections such as upper, lower, and vertical intermediate sections are delivered as preassembled side plates, coverings, and connecting consoles.

