Technical description
DT.FL.14 Rev.2

AUTOMATIC FURNACES
CHARGING MACHINE

SAPA Heat Transfer
Finspang, Sweden

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# Automatic Furnaces Charging Machine

## 1. SUBJECT

This technical description refers to the supply of one **Automatic Furnaces Charging Machine** to load scrap and solid metal into Aluminium melting furnaces and the **systems to handle the charging boxes in the filling area**.

In particular, for the proposed equipment the supply includes:

- Design
- Construction
- Purchasing of commercial components
- Transport
- Installation
- Testing and Customer training
- Quality control

as detailed below.

## 2. GENERAL

The charging equipment for Aluminium melting furnaces described below is designed to carry out the following operations:

**a) AUTOMATIC FURNACES CHARGING MACHINE, rail mounted:** to load Aluminium scrap consisting of slit coils, coil ends, scrap pocket, slab ends, slab sides, hot rolled sheets and T bars, into the melting furnaces. The charging machine travels on rails between the charging boxes handling position and the melting furnaces, and introduces the charging box to load the scrap into the furnaces.

**b) CHARGING BOXES LIFTING/LOWERING TABLES:** located in the scrap area opposite to the furnaces, take the empty boxes from the Automatic Charging Machine; deliver to the Automatic Charging Machine the full boxes which have already been filled by mean of a front loader to the Automatic Charging Machine, to allow a new furnaces charging cycle to start.

## 2.1 AUTOMATIC FURNACES CHARGING MACHINE

Proposed **AUTOMATIC FURNACES CHARGING MACHINE** optimises the scrap loading operations into the melting furnaces ensuring efficient and effective operations, saving energy, preserving furnaces and keeping operators in safe positions avoiding exposure to risks while loading scraps in the molten bath. The machine serves both furnaces of the actual project and can easily upgraded to serve similar furnaces of future expansions.
The size of the boxes has been dimensioned to fit the existing furnace, while the new furnace will be loaded in two positions (as shown in the layout drawing); the boxes will be filled on the loading stands (pantograph type lifting or lifting and rotating platforms) and then picked up by the machine.

To reach the melting furnaces after the box with scraps has been engaged at the scrap area, the charging machine travels on the rails, controlled by PLC and lasers scanning the surrounding area; the position is checked by a measurement laser, which instructs the machine to reach accurately the targeted positions. Acceleration, travelling speed and deceleration of the machine are managed by the PLC which controls the frequency converter (inverter) of the traction motor.

The system doesn’t require any operator on board, just the choice of scrap box to be picked up and the destination at the furnaces must be selected by the operator to start the furnace charging sequence.

Charging of scraps into the furnace is done when the charging machine is properly positioned in front of the furnace.

After the furnace door has been opened (where present) the charging machine forwards the box inside the furnace and then the back wall of the box is moved forward to push the scrap into the melting chamber, so that:

- the new material is progressively unloaded into the furnace, pushed by the mobile back wall of the box
- the amount of material unloaded into the furnace is controlled and uniformly distributed (scrap is easily distributed thanks to coordination of the forwarding movement of the mobile back wall and the retraction of the box itself).

Following drawing visualises furnace section during charging phases:

The upper deck of the machine supporting the charging box can be rotated to have box facing the furnaces or the box lifting tables at the box filling area.

The charging box is a removable part of the machine and is designed to be easily changed: the empty box is left so that a new one full of scrap can be quickly engaged.

The Automatic Furnace Charging Machine can fit different types of charging boxes:

- boxes without front door to be used to load heavy scraps, easy to handle from the front opening;
- boxes with front door to load the loose scrap (chips, etc.) in this case the door allows to use the entire nominal volume of the boxes with the light material (density 1 ton/m³ or less); front door is hinged at the top (flap type front door) to avoid scrap is pulled back on the box after it has been discharged even in case its level is higher than box bottom.
As below described in details, at filling positions the charging boxes are on lifting tables which after receiving the empty box from the machine lower them (and if the case also rotate) to facilitate filling operations with the wheel loaders.

The supervision system checks all the operations, allowing or denying permissions depending on position of the charging machine and on conditions of interlocked items (furnaces door, furnaces tilted, box lifting tables, etc.).

2.2 SYSTEM TO HANDLE THE CHARGING BOXES

Benefits associated with the charging machine are increased by the systems to handle the charging boxes in the scrap area, which thanks to the additional scrap boxes in operation will reduce significantly the time necessary to complete the loading cycle of the furnaces, since the box full of scrap will be filled without stopping the machine (which after changing the box will be immediately ready to start a new furnace loading cycle).

The systems to handle the charging boxes in the scrap area consists of proper lifting / lowering tables, with hydraulic cylinders powering pantograph levers; those for boxes without front door will be equipped also with table rotating device. Total number of Charging Box Lifting Lowering Tables can be increased at any time to follow production requirements.

A typical operation sequence of the systems to handle the charging boxes is as follows; the empty box is filled with forklift trucks or front loaders in the scrap area (this is done away from the charging machine not interfering with the furnaces charging cycles in progress). Once the Furnaces Charging Machine reaches the scrap area to leave the empty box and receive a full box, the following sequence is executed in a short time:
a) the Furnaces Charging Machine reaches the free box position and rotates the upper deck to align the box with the lifting table (ref. 1A),
b) the Furnaces Charging Machine forwards the empty box over the lifting table (ref. 2A)
c) the lifting table is raised to disengage the box from the machine which then retracts the box holding support and moves to a different position (after selection by the operator of the box to be engaged) to pick up a new box already filled (ref. 3A)
d) the table with the empty box is lowered to start filling procedure; in case the box is without front door to facilitate filling with heavy scrap, big saws, T bars, etc. from the front opening, it is rotated to have the front opening facing the driving direction of the front loaders (ref. 4A); in case the box is with front door it is not rotated (ref. 4B)
e) after the box has been filled it will be raised again by the lifting table and the operations will be repeated in opposite sequence to have the box on board of the Furnaces Charging Machine to start a new furnace charging cycle.

Since the loading of the next charge of the box is performed in parallel to the furnace charging cycle, and because the actual furnace charging time is so quick, furnace productivity can be highly increased.

Each stand has an integrated weighing system to measure the weight of the material in the box during the load operation.

Red/green traffic light at the end of the ramp to access the area will deny/give permission to the front loaders and fork trucks to access the area, depending on position of the Automatic Furnaces Charging Machine.

2.3 Advantages

Having manufactured furnace charging and tending equipment since more than 10 years at T. T. Tomorrow Technology the path of the development of the Aluminium melting technology is well known. The economic and production advantages achieved by the furnaces charging systems are well proven by the current use of these machines and can be summarized as follows:

a) **Increased productivity**, while programming, respecting and controlling the furnace loading times and cycles (scrap loading into the box is not affecting the cycle of loading the scrap into the furnaces thanks to the additional boxes in operation, one on the machine and other in the scrap area for being filled);

b) **Accurate and rapid execution** in carrying out the operations described above;

c) **Increased operators safety**;

d) **Reduction of the furnace door opening time**, consequently **reducing**:
   i. energy wastage (**reduction of gas consumption**);
   ii. metal losses due to oxidation;
   iii. adsorption of atmospheric hydrogen;
   iv. loss of productivity during loading and for the time necessary to bring the furnace back up to operating temperature;

e) **Avoided damage to the refractory lining** of the furnace vault and walls since the accuracy of the automatic positioning avoids the risk to hit the refractory lining of the furnaces;

f) **Prolonged life of the refractory lining** due to reduction of thermal stress and shocks with relevant repeated strong shrinkage and dilatation cycles;
g) Free the area in front of the furnace hatch when the rail charging machine is in rest position.

It is noteworthy how the rail charging machines will need a very short time (approx. less than 30 seconds/batch) to discharge the scrap into the melting furnaces. Depending on scrap density and type, only 3 or 4 batches should be sufficient to completely load the furnaces. This should be compared with the time required when conventional means (fork lifts, front loaders, etc.) are used, usually 45 to 60 minutes.

The sum of all the above mentioned benefits is a result of the reduced door opening time. In a plant where total throughput is constrained by the furnaces charging time, the installation of a dedicated charging machine will pay for itself very quickly.

3. REFERENCE OPERATING CONDITIONS

T. T. Tomorrow Technology S.p.A. can show a well proven references list for the entire range of vehicles and automatic systems for Aluminum smelters and recycling plants. The recent realizations of the automatic equipment for loading the melting furnaces give our Company an important leadership in the scenario of the cast houses, not only for the Italian clients but also for international customers.

To really boost furnaces performance, the management of today complex melting systems has to be committed to equipment as much specialized, reliable and efficient; the use of the dedicated systems has been proved to be the indispensable replacement of conventional vehicles formerly used in the cast houses (fork trucks, power shovels, front loader, etc) for the furnaces tending operations.

Equipment specialized in furnaces tending operations have demonstrated to increase the productivity, to reduce energy consumption, enhance personnel safety and ensure a better environment condition in the cast houses and refining plants where they are in use.

Catalogue machines, designed and manufactured for different purposes, which are only controlled by operators (and sensitive to human errors and operations variability) are no longer able to provide any of the standards today required, therefore it’s easy to understand how the automatic systems make possible to achieve levels of automation, precision, speed and safety so far unthinkable for conventional vehicles. The accuracy of the operation and the regular schedule for the sequence of the automatic systems meet the management needs of the most advanced smelting furnaces.

Furthermore, when installing the AUTOMATIC FURNACES CHARGING MACHINE in the furnace area, operated from the control room, you will be able to charge the furnaces without the presence of operators in front of the furnaces, still maintaining full control of the operation.

The specific requirements of the customer related to the loading cycle have been evaluated, considered and included in the design definitions of the proposed rail charging machines, combining them with the experience gained in the realisation of similar projects.

The dimensions of the furnaces to be loaded considered for the proposed rail charging machines as well as the lay out are in accordance to SAPA drawings 5042599 rev 37 and 5042597 rev 37.

The machine described is intended for operation in the following conditions:

- Altitude ........................................................................................................ 0 ± 100 m above sea level
- Ambient temperature .................................................................................. -10 ± 45°C
- Relative humidity.......................................................... 30 ± 100 %
- Environment.......................................................... dusty
- Type of operation.......................................................... continuous
- Minimum hourly charging capacity (as required by SAPA spec.).................. 15 ton/h

4. **REFERENCE STANDARDS**

The machines and systems described herein comply with the following laws, regulations and standards in force on the date of printing:

- UNI standards
- ISO standards "International Standard Organization"
- IEC/CEI standards "International Electro technical Commission"
- EEC Directives 2006/42 "Machine Directives"

5. **TECHNICAL FEATURES**

Main catalog components manufacturers are:

Motor reducers and gear boxes SEW
Hydraulic cylinders Rexroth / Parker/ Tomorrow Technology
Hydraulic pumps and motors Rexroth / Sauer Danfoss
Hydraulic valves Rexroth / Sauer Danfoss
Electric motors: ABB / SEW
PLC, HMI, and controllers Siemens
Inverters and drives SEW
Electric power and control components Siemens / Telemecanique / IFM
Electrical cabinets Rittal
Scan laser, laser, optical barrier Leutze / Allen Bradley / Rockwell A. / IFM
Pressure and temperature sensors IFM, Danfoss, Telemecanique
Proximity switches Baluff
Mechanical switches Telemecanique / Siemens
Bus Bar Demag / Cariboni / Zucchini

(different manufacturers may be discussed and agreed upon on Client request)
**Dimensions, Weights and Operating features**

**AUTOMATIC FURNACES CHARGING MACHINE**

- Length ........................................................................................................... 6.700 mm
- Width ............................................................................................................... 4.500 mm
- Height ........................................................................................................... 2.800 mm
- Rail span ....................................................................................................... 4.500 mm
- Rail section .................................................................................................... A100
- Machine operating weight (box empty) ....................................................... approx. 30.000 kg *
- Inside box dimensions .......................................................... 2.900 x 3.280 x 1.080 (h) mm *
- Box volume .................................................................................................. 9.5 m³ *
- Net loading capacity ........................................................................................ 10.000 kg *
- Installed hydraulic power ............................................................................. 38 kW *
- Traction ........................................................................................................... electric with frequency converter and gear reducer, 11 KW
- Translation speed with full load ..................................................................... max 40 m/min
- Maximum sound level at 1 m from the machine .......................................... 80 dB (A)

**SYSTEM TO HANDLE THE CHARGING BOXES**

Each Lifting / Lowering table has the following characteristics:

- Length ........................................................................................................... 3.000 mm *
- Width ............................................................................................................... 3.000 mm *
- Height (low/high position) ............................................................................. 700 / 1.800 mm *
- Height with rotating table (low/high position) .................................................. 1400 / 1.800 mm *
- Allowed rotation of rotating table (where present) ....................................... up to 180°*
- Machine weight (empty) ................................................................................ approx 6.000 kg *
- Lifting capacity (nominal) ............................................................................. 20,000 kg

- Installed power for hydraulic unit, unique for all the tables (preliminary) ........ 11 KW *

*Note: The data marked with (*) are preliminary; can be modified according to the customer’s requirements*
6. **EQUIPMENT DESCRIPTION**

**AUTOMATIC FURNACES CHARGING MACHINE**

- **Frame**
  - Composed of a custom designed and robust electro welded framework;
  - Support for wheel units;
  - Support for fifth wheel and rotation joint;
  - Support for scan laser;
  - Wheels unit, proprietary design, with steel wheels, bearings, easy to change wheel supports;
  - Traction unit powering two wheels, with self braking electric motor, gear reducer, joints and shafts;
  - Carters and protections of mobile components;
  - Towing points for emergency operation;

- **Rotating deck**
  - Composed of a robust electro welded framework
  - Counterbalanced with ballast at the rear
  - Supports and guides for sliding frame (carriage) holding the scrap box, with a stroke to reach inner part of the furnaces
  - Racks and pinions (powered by hydraulic motors) system for the movements of the carriage holding the scrap box
  - Housing hydraulic power and control unit
  - Fifth wheel secured to the lower machine frame
  - Rotation movement made by pinion (on hydraulic motor) and teeth of the fifth wheel

- **Scrap discharging system**
  - Charging box carriage and telescopic unit support, composed of a robust mobile frame with appropriate housing for the sliding rollers, side guides and hydraulic motors for the telescopic movements; the charging box carriage positions the charging box inside the furnaces at the position where the scrap will be discharged;
  - Telescopic unit consisting of a double section robust electro welded steel pusher of proprietary design, suitable for the movement of the back mobile wall of the charging box to push the scrap inside the furnaces. The first section is powered by hydraulic motors with a rack and pinions transmission system, the second by hydraulic cylinder.
  - Hooks and safety pins to lock the charging box to the carriage
  - Charging box in alloy steel suitable to resist thermal stress entering end exiting the furnaces melting chamber, complete of pins for connection to the supporting carriage, mobile back wall (to push the
scrap out) mounted on combined support bearings of proprietary design, mobile wall bottom scraper; with (or without, depending on type) hinged front door. Design of box structure and of the bottom frame to resist to hits of heavy material; construction steel (Hardox Steel bottom i.e. wear resistant steel plates for high performance applications ensuring excellent combination of strength and hardness) suitable and already proven to face the extreme wear working conditions of the furnaces charging machines.

- **Hydraulic system**
  - Open circuit for all the services of the machine with variable displacement pump
  - Maximum pressure valves
  - Proportional valves with electronic/hydraulic control
  - Hydraulic motors for scrap carriage movements
  - Hydraulic motors for main telescopic unit movements
  - Hydraulic motor for the rotation of the upper deck
  - Hydraulic cylinders for the locking of the box on the support carriage
  - Tank with levels, control fillers, air breather filters, etc.
  - Pressure switches, heat exchanger, oil filters, etc.

- **Electric system**
  - Power circuit tension: 400 V AC / 3 phases
  - Frequency: 50 Hz,
  - Control circuit: 24 V DC/AC
  - Total installed power: 59 KW (*)
  - Circuits and panel protection: IP 54
Note: The data marked with (*) are preliminary; can be modified according to the customer's requirements

- **Main Electrical Board** (positioned on the wall in the area of the scrap boxes lifting platforms)
  - Rittal cubicles series AE, color code RAL 7035, mounted on wall
  - Protection degree IP54.
  - Auxiliary/controls voltage 24V DC.
  - Power supply cables entrance and connection from bottom.
  - All components of the cabinets, terminals and wires are numbered.
  - Wires are closed in special plastic trays equipped with covers.
  - 20% free space left for future expansion.
  - Weidmuller spring terminals.
  - Power supply 400 V, three-phase, 50 Hz, ISC 35 KA.
  - Three-pole main switch with under voltage release coil and Siemens lockers, padlocked internally and externally.
  - IME digital instrument model type Nemo for reading of volts and amps with other functions like peak current, etc.
  - Botter transformers.
  - Siemens power supply unit Sitop series.
  - Siemens pushbuttons.
  - Power and control sections of the hydraulic power unit for the lifting tables;
  - Siemens circuit breakers and contactors Sirius series for motors control; cables which go to motors are directly connected without passing into intermediate terminals.

- **Local Operator Control Panel** (located in the area of the scrap boxes lifting platforms) it contains CPU and interface cards, as well as HMI panel for control of the operation and cycles as per above description, alarms visualization, alarms history records, automatic and manual mode selection, etc.;
  - Rittal pulpit 800mm wide (article 6715500 + article 6721500) with base of 100mm height for cables entrance; it will be completed with one Emergency pushbutton and one emergency circuit reset key.
  - Siemens CPU 315-2PN/DP Safety, 2 MByte memory.
  - Siemens Ethernet card with Softnet protocoll.
  - Siemens Profinet switch 8 lines RJ45 Scalance X208
  - Siemens MP377 12” touch screen operator panel, installed on pulpit and connected to PLC via Profinet.
  - N 2 Siemens Rapid Roaming Access Points for Wireless communication
- **On Board Panel(s):** electrical panel(s) on board on board of the Furnaces Charging Machine, with power and control sections;
  - Rittal cubicles series AE, color code RAL 7035 (preliminary)
  - Power supply cables entrance and connection from bottom and sides.
  - All components of the cabinets, terminals and wires are numbered.
  - Wires are closed in special plastic trays equipped with covers.
  - 20% free space left for future expansion.
  - Weidmuller spring terminals.
  - Control of the hydraulic power unit located on board of the Furnaces Charging Machine
  - Control of a translation motor with relevant frequency converter and braking resistance
  - N 1 Siemens Rapid Roaming Access Points for Wireless communication
  - N1 Siemens Profinet/Profibus converter

The automation control of the supply shall be completed by the installation of the followings:
- N 3 Profinet cards Siemens ET200-S Safety (preliminary).
- Digital input cards Siemens ET200-S Safety 24VDC with 4 points, spring terminals (preliminary).
- N 3 digital output cards Siemens ET200-S Safety 24VDC with 4 points, spring terminals (preliminary).
- Analog input cards Siemens ET200-S
- Output analog card Siemens ET200-S
- Digital input cards Siemens ET200-S 24VDC with 4 points, spring terminals
- Digital output cards Siemens ET200-S 24VDC with 4 points, spring terminals
- WI Lan connection with the panel of the Furnaces Charging Machine, Rcoax cable antenna 52 m supported by the the power bus bar supporting beam;
- Ethernet connection to the data network of the plant for furnaces interlock exchange and Citec SCADA dialogue;
- Laser measuring system for position control;
- Weighing system of the scarp boxes on the lifting tables and profibus connection to the PLC;
- Control devices (laser, proximity, sensors, transducers, encoders, photo cells, etc);
- Scan lasers for safety area detection;
- Color lights for machine status indication and sound alarm, red/green light for area access permission;
- Beeper for machine operation and alarms;
- Control and power cables laid in raceways, conduits or flexible shields;
- Junction and pull boxes;
The battery limit of the electrical system is the inlet board of the main switch; communication with interlocked equipment (furnaces, etc.) will be via Ethernet interface.

**The control architecture of the system is below represented**

- **PLC SOFTWARE**
  The PLC software, supplied with comments and symbols, will have following functionality:
  - Diagnostical control – the event will trigger an acoustical and visible signal, involved equipment will be stopped (motors, valves, etc...) and a message will be shown on the operator panel installed.
    - Manual mode – for starting and stopping each single motor and valve. The system will maintain the safety control for each unit.
    - Automatic mode – automatic cycle for starting and stopping the machine with predetermined sequence, machine automatic stopping after specific faults.
    - Semi Automatic mode – semi automatic cycle as above but with single step to step validation by operator;
  - Operator Process management by mean of possibility of selecting furnace destination and scrap box to be used.
- **OPERATOR PANEL AND SUPERVISION SYSTEM SOFTWARE**
  Graphic pages, alarms and all necessary tags will be developed according to operation requirements. The software used for the panel will be Siemens WinCC Flexible. The software for the supervision system will be Citec of Schneider.
  It will be possible to select the operator panel mode in English or Swedish language.
  The graphic pages provided will be as follows:
  - Synoptic of the plant with relevant status.
  - Selection Annual/Automatic operation mode and manual control page(s).
  - Pages for machine, drive speed and recipe parameter settings (cut length, cut start point, cutting angle, etc.).
  - Alarms page(s).
  - Production reports and statistics.

- **ELECTRICAL PLANT CONNECTIONS**
  Includes all cables, cable trays, conduits and sheaths with accessories for connection to motors, valves, emergency pushbuttons and all necessary sensors for the plant operation.
  Cables are OLFLEX type (oil resistant), with appropriate section of the load to be powered considering the voltage drop and in any case not less than 2.50mm² for motors and 1.50mm² for auxiliaries not already wired or with connectors which receives lower sections. All cables are equipped with terminals and identifying plates in accordance with the electrical wiring diagrams.
  All installed components will be identified with engraved white plastic nameplates in accordance with the electrical wiring diagrams.
  The cable trays will be closed by galvanized steel covers or open cable trays (Cablofil type), with different dimensions, sized with a reserve of 10% free space, complete with brackets and fittings.
  The armed sheaths are RTA type with various sections complete with connection and mounting accessories suitable for ensuring the protection level IP54.

- **BUS BAR POWER FEEDING SYSTEM**
  Power supply to the mobile Automatic Furnaces Charging Machine will be via compact power supply line and mobile trolley. The system consists of modular elements with 4 copper conductors protected by housing and a sliding trolley fixed to the support arm of the Automatic Furnaces Charging Machine. The bus bar elements are supported by suspension brackets held by a steel section beam which is supported by strong brackets fixed to the existing columns of the building, as detailed in the attached drawing.
  The power supply line has nominal capacity I = 100 A; total length 52 m.
Buyer shall keep action to prevent and/or protect from risk of collision of the over head crane elements and other mobile equipment with the power supply line and its supporting beam and brackets.

- **Safety devices and protection grids**

Protection of personnel and equipment in the working area of the Automatic Furnaces Charging Machine is provided by 4 multizone Safety Scan Lasers whose configurable detection fields, both for warning and safety zones, ensure required safety standards in a flexible way.

The pantograph mobile tables of the scrap area shall be protected with protection grids and interlocked door to access the area; one multizone Safety Scan Lasers completes the safety installation in this area to avoid operator sexposure to potential hazard while the upper part of the rotating platform moves.

One red/green traffic light at the end of the ramp to access the area will deny/give permission to the front loaders and fork trucks to access the area, depending on position of the Automatic Furnaces Charging Machine.

- **Painting**
  - Removal of welding/grinding slag, sandblasting
  - 45-micron primer
  - 50 + 50-micron top coat
  - Caterpillar yellow

- **Testing**

The final machine construction phases include a series of tests that will be conducted both at our and the customer's facilities

Testing comprises:
  - Inspection and testing of the basic machine functions as provided for in the sale contract
  - Inspection and testing of the translation system
  - Inspection and testing of the service hydraulic circuit
  - Inspection and testing of all the hydraulic components
  - Inspection and testing of the electrical and electronic equipment
  - Tests of the controls relating to machine safety
  - Functionality tests
  - Full load tests (at customer site) and performance tests
7. **EXCLUSIONS**

The followings are not included in the scope of supply:

- Rails and relevant installation;
- Any civil work and civil works to fix supplied items;
- Lights in the working area;
- Air and dust aspiration and filtration;
- Fire fighting system;
- Software developing licences for Siemens S7 and Win CC flex;
- Over head crane and mobile equipment prevention/protection from risk of collision with power feeding system;
- Raw material and production consumables for tests;
- Any accessory, supply or service not above specified.

8. **ATTACHMENTS**

- Drawing DT.FL14 sheet 1/4 rev.B (overall dimensions)
- Drawing DT.FL14 sheet 2/4 rev.A (charging operations)
- Drawing DT.FL14 sheet 3/4 rev.A (change box fases)
- Drawing DT.FL14 sheet 1/1 rev.0 (bus bar lay-out)

For any technical and commercial information please contact

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