Examples of Technology to Improve Quality beginning from Development to Production for Steel Strips

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  - Process Simulators for Steel Grade and Process Development
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  - Condition Monitoring Systems for Preventive Maintenance
  - Laboratory tests for retained austenite
- Future prospects

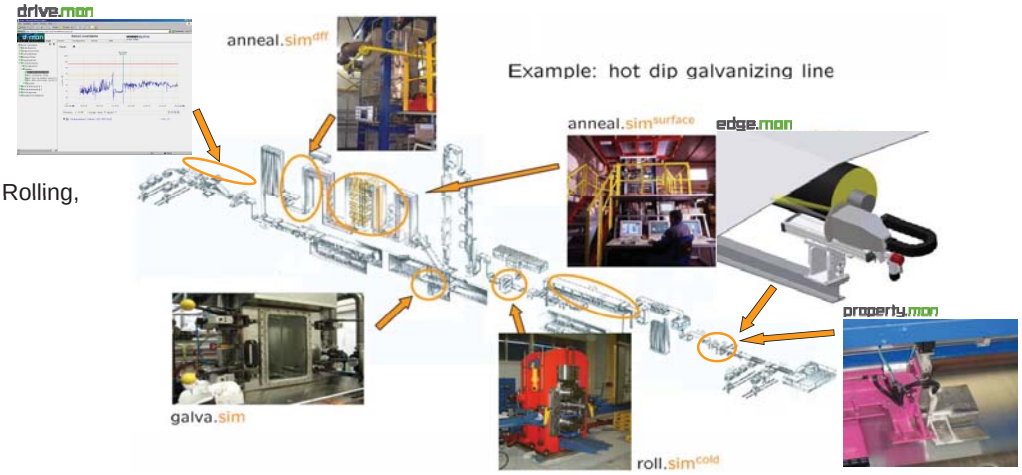
drive.mon
vib.mon
edge.mon
roll.sim cold
property.mon
anneal.sim structure
galva.sim

The vatron Quality Assistance Philosophy

1. Identify the important process steps
2. Separately simulate these steps
3. Monitor the production process with respect to the results
4. Monitor the production plant with respect to reliability and output

Vatron operates in the fields of

- Steel Industry: Steelmaking, Casting, Rolling, Annealing, Galvanizing, Coating
- Steel treatment industry
- Non ferrous metals
- Mechanical engineering
- Chemical industry
- Plastics- & paper industry
- Environment & energy
- Cement / lime / gypsum



Steel Grade and Process Development

- Results must be transferable to the industrial situation. Verification of test results in line trials ensures the quality and effectiveness of product and process development.
- Specimen size must be sufficient to allow material characterization as well as determination of application properties.
- Systematic parameter variations must be possible in a very defined way with a high level of reproducibility.
- Testing of process parameters which are not realized on existing lines - giving the possibility of testing very exotic and innovative materials or process steps
- High productivity, which means test runs which are easy to handle for a single operator with high throughput at comparatively low costs.
- Generous installation of sensor equipment that is to some extent not even possible in the industrial line.
- For easy evaluation the measurement values must be stored in a central data base.

Steel Grade and Process Development

In order to strength the position there is a clear trend from premium steel producers to build technology centers as a core area for development, a research facility equipped to simulate the entire process chain, ranging from the manufacture to processing of steel on the lab scale.

Experimental simulation starts with an analysis concept derived from experience in the manufacture of this steel grade, standardized or customer requirements, as well as operational possibilities. A test cast is produced on a laboratory scale and then hot rolled and cold rolled. Thanks to investments in a technology center, with the simulator equipment for hot and cold rolling / skin passing, annealing and hot-dip coating, it is now possible to close the continuous process chain for steel manufacture in the laboratory.

Steel Grade and Process Development

galva.sim – Simulator for heat treatment and galvanizing process

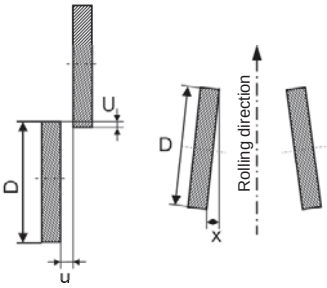
- **one example for our big range of simulators**
- **annealing - galvanizing**

… a picture tells more than a thousand words …

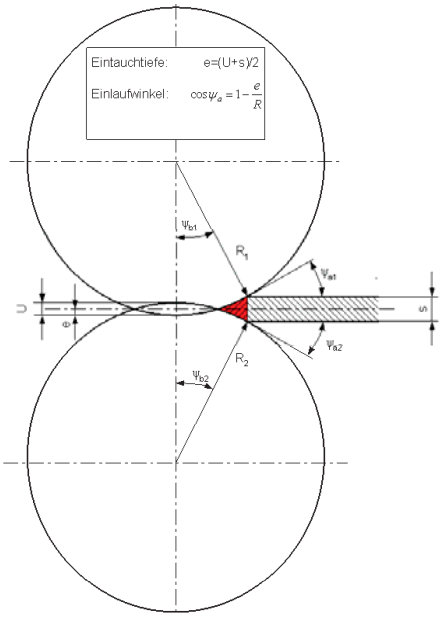
Inspection of Edge Surface Quality

Influence edge quality

- Main parameters
  - Overlap U
  - Gap u
  - Pre-track x
- Condition of knife
  - Abrasion of knife
  - Defects like knife-breakouts
- Used materials, plant settings
  - Steel grade of knifes
  - Steel grade of strip
  - Plant speed



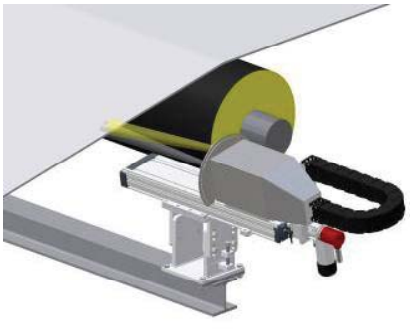
Gap Pre-track

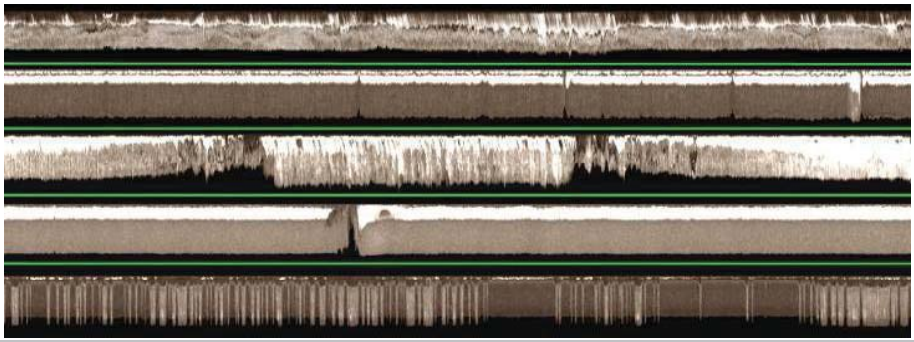


Inspection of Edge Surface Quality

Moveable sensors - typical for finishing line applications

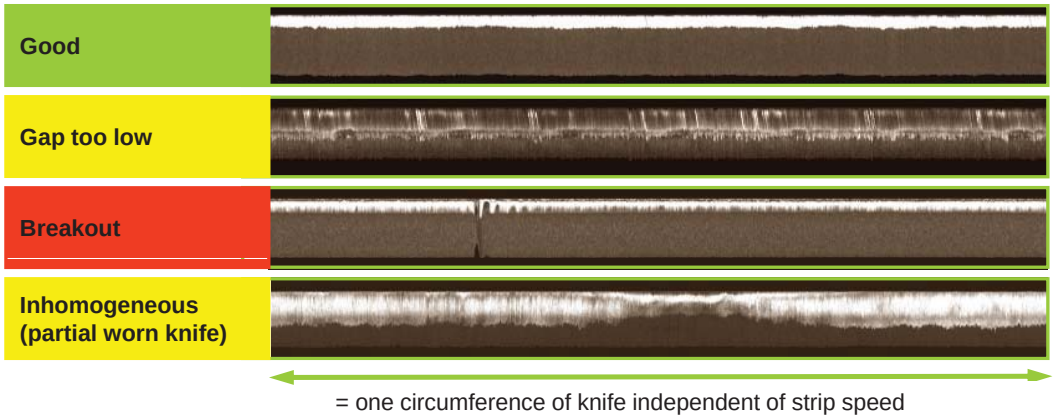
- Synchronization with knife circumference, Image quality independent of width, thickness, speed
- 100 % inspection of the strip
- Determination of the C/B ratio
- Detection of knife breakouts
- Detection of general bad edge quality
- Burr measurement with threshold warning optionally





Inspection of Edge Surface Quality

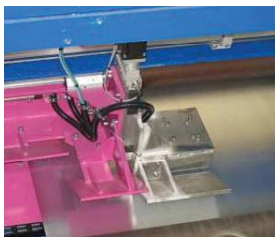
Examples of edge defects detectable with edge.mon
(yellow = automatic edge quality warning, red = automatic knife breakout alarm)

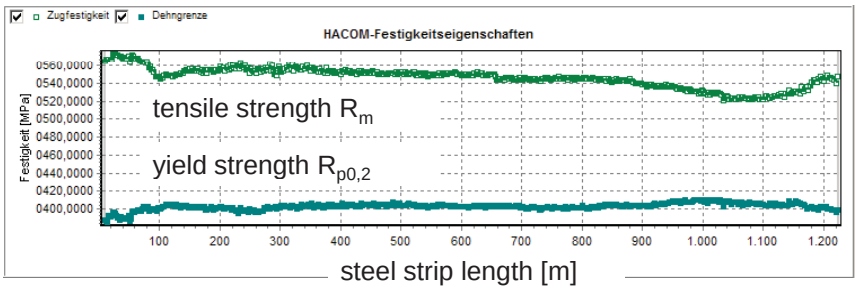


Measurement of Mechanical Steel Strip Properties

testing of steel strip properties (tensile strength, yield strength)

- in-line measurement of yield strength and tensile strength
- non destructive, contact less
- immediate results





Measurement of Mechanical Steel Strip Properties

material state

- **alloy composition**
- **structure**
- **grain size, texture**
- **dislocation, chemical deposition**

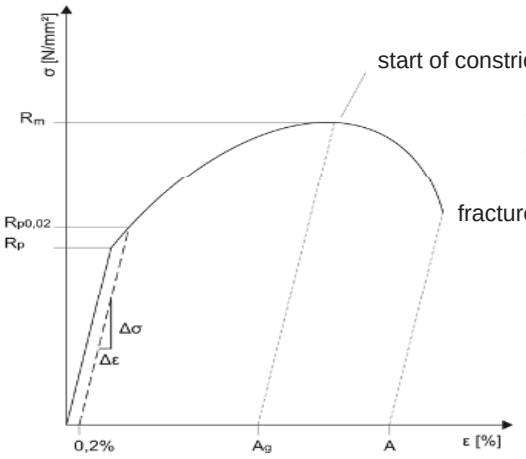
mechanical characteristics

- **strength**
  - yield strength, tensile strength
- **hardness**
  - surface-, corehardness
  - hardness penetration depth
- **ductility**
  - strain hardening exp., anisotropism

magnetic characteristics

- **electrical conductivity**
- **magnetic properties**
  - hysteresis loop, permeability coercive field strength, remanence
  - directional dependency of harmonic eddy current signals

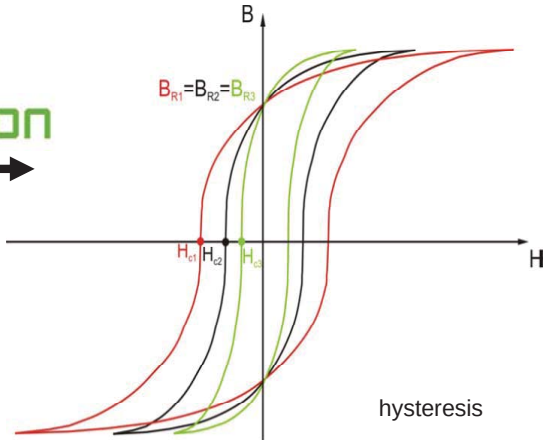
Measurement of Mechanical Steel Strip Properties



start of constriction

fracture

property.mon



hysteresis

Measurement of Mechanical Steel Strip Properties

Measurement of Mechanical Steel Strip Properties

Research focus…	… achieved by…
Increased quality resulting from advanced process **optimization** and control with respect to **capacity, energy and output**…	… by use of the latest and most advanced in-line measurement system for **mechanical properties characterized by the whole hysteresis loop**
Save scrap or **downgraded material**…	…by precise measurement of the mechanical steel strip parameters with immediate recognition of **deviations** in the **alloy composition or process parameters**
Save scrap by knowing the **optimum cut position** at the beginning and at the end of the strip…	… by **true measurement** device where no plant parameters are required for inline measurement of mechanical properties
Easily and time-saving to compare and evaluate with the laboratory tensile strength test for **quality documentation**; Reduce number of tensile strength tests (delay, time consuming)…	… because measurement occurs through the **complete steel strip thickness**
Save scrap and reclamations by **deviations across** the strip…	… by **traversing measurement** across the entire width of the steel strip with close-to-edge measurement (optionally)
Low **maintenance** for reliable results…	… by self check of **system condition** (sensor status, measurement chain, data acquisition)
Product improvement especially for **silicon steel**…	… by **direction related measurement** (optionally) along and across the strip
Technology advantages…	… by **examination of the process** in respect to additional information coming from the measured values representing the electro-magnetic properties (hysteresis loop)

Early Fault Detection in Drive Trains

Functionality

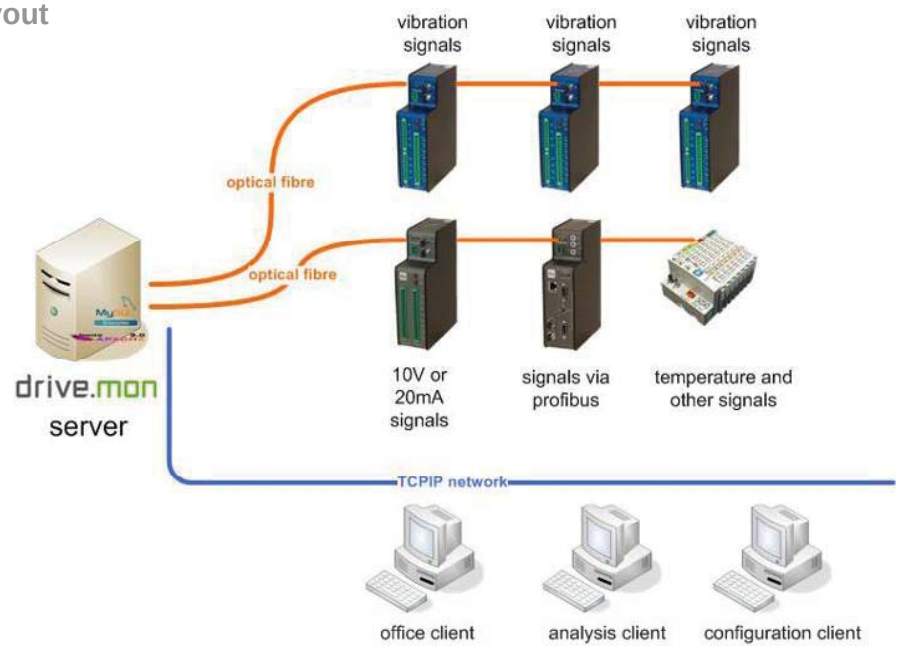
- periodic vibration measurement
- automatic fault level calculation
- fully configurable auto analysis
- automatic alarming via e-mail or SMS
- database assisted long term trending
- easy access via webbrowser
- easy to use for both experts and beginners
- integrated expert signal analysis tools

Benefits of early fault detection

- saving repair costs
- optimizing yield performance
- effective repair work
- saving logistics costs

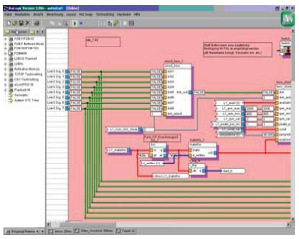
Early Fault Detection in Drive Trains

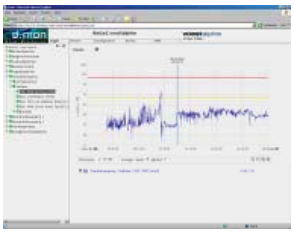
System layout



Early Fault Detection in Drive Trains

Measurement and analysis





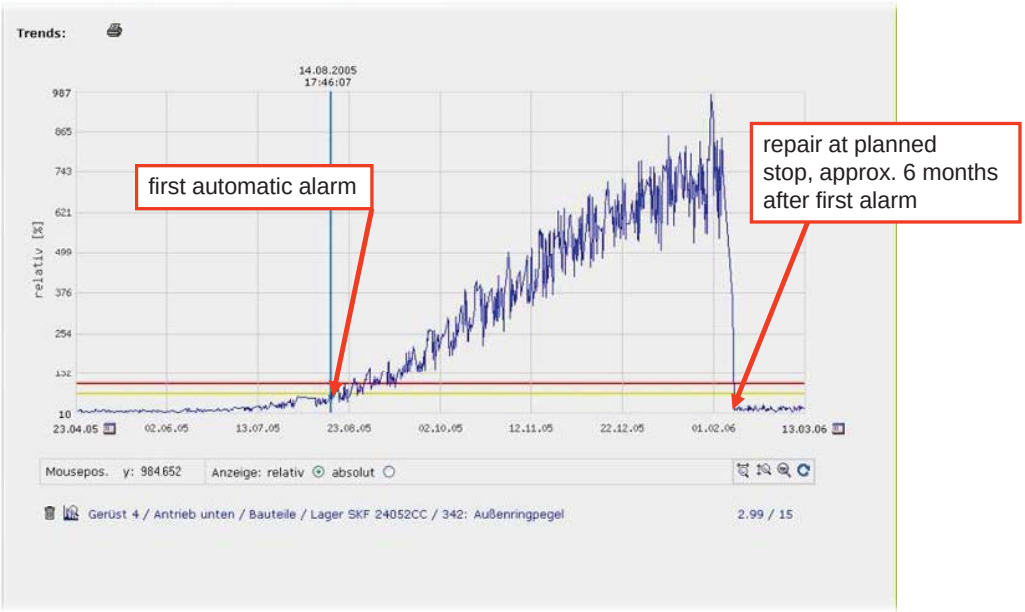
data acquisition
- parameters
- plausibility checks
- raw data storage

analysis server
- plausibility checks
- automatic fault analysis
- alarming

web interface
- configuration
- trending
- manual analysis

Early Fault Detection in Drive Trains

Fault example



trend of bearing level

Early Fault Detection in Drive Trains

Fault example

visual inspection confirms drive.mon alarm

without online CMS

- severe consecutive damage
- probable total loss of gearbox
- massive production loss

with drive.mon

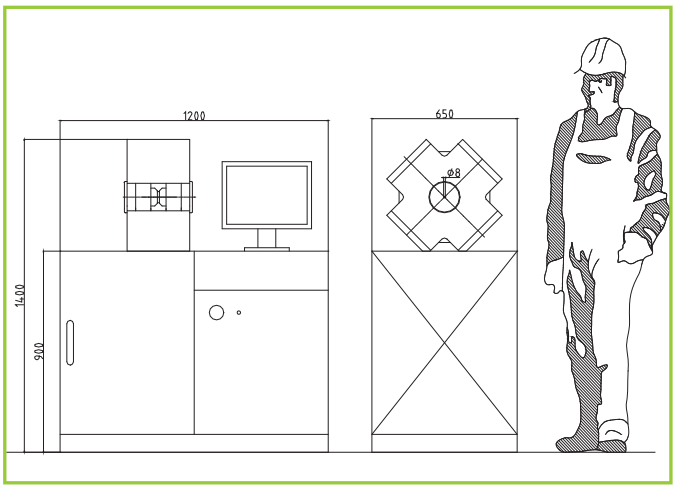
- repair costs saving 75%
- repair work scheduled in regular production stop

Measurement of Retained Austenite

The amount of austenite is a very important parameter for high quality steels. E.g. the tensile strength of TRIP-steel (TRIP = Transformation-Induced Plasticity) depends on the amount of retained austenite in it.

Various methods have been used to determine the amount of retained austenite (e.g. Schäfflerdiagram, x-ray-diffractiometry). But all these methods have a low reproducibility or are not easy to handle.

The application of the magnetic yoke of vatron is based on the fact, that ferrite and austenite differ completely in their magnetic behaviour. Ferrite with its bcc structure is a magnetic material whereas austenite with its fcc-structured atomic lattice is non-magnetic.



Measurement of Retained Austenite

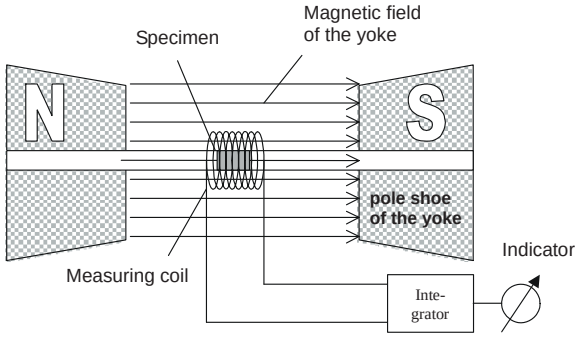
When a ferritic specimen is brought into a magnetic field it is magnetized. Is this magnetized specimen pushed through a measurement coil a voltage pulse is induced in the coil. The magnetization is proportional to the integral of the voltage pulse.

$J_m \propto \int U_{ind}\,dt$	J_m:	Intrinsic induction of the specimen
	U_{ind}:	Induced voltage in the measuring coil

Austenitic material does not show this behaviour. This means the higher the amount of austenite in a sample is the lower is Jm.

So, in the case of magnetic saturation Jm can be used to calculate the amount of retained austenite in the measured samples. For this theoretical intrinsic induction the austenite-free material of the same chemical composition is needed. This can be calculated as follows.

$J_s^{Fe} - \sum \alpha_n A_n$	J_s^{Fe}:	Intrinsic induction of pure iron in the state of saturation
	α_n:	decreasing factor of element n
	A_n:	Amount of the element n in the specimen



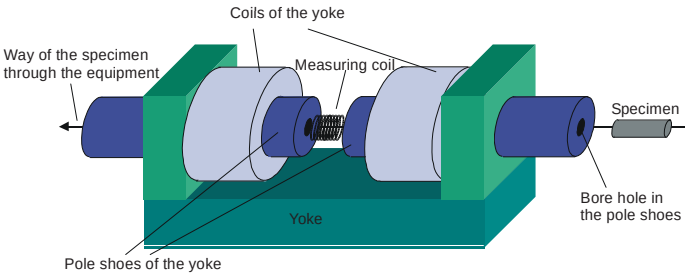
The intrinsic induction of pure iron in the state of saturation and the decreasing factors are known from literature. The amount of retained austenite now can finally calculated to:

$$A_{aust}[\%] = \frac{J_s^{Fe} - \sum \alpha_n A_n - J_m}{J_s^{Fe} - \sum \alpha_n A_n} \cdot 100\%$$

A_{aust}	Amount of austenite in the specimen
J_s^{Fe}	Intrinsic induction of pure iron in the state of saturation
J_m:	Intrinsic induction of the specimen
α_n:	decreasing factor of element n
A_n:	Amount of the element n in the specimen

Measurement of Retained Austenite

- Easy to use PC-program
- any shape of the specimen possible
- Measuring range for austenite in ferritic steel: 1% - 30 %
- Measuring range for ferrite in austenitic steel: 1% - 30 %
- Reproducibility: ± 0.5 %



- Weight: 500 kg
- Magentic field strength: 20 000 A/cm
- Power supply: Threephase current: 380 V-480 V
  7kVA (for the yoke)
  110 V-220 V (for the PC)
- Cooling water: 4 l/min / min. 3,5 bar
- Water connection: 6 mm ∅
- PC: Pentium III or higher, 128 MB RAM or more
- Operating system: Windows 2000 or Windows XP
- Dimensions of the specimen: length: ≤ 15 mm

Summary and Outlook

- Introduction vatron
- Quality aspects for development and production of steel grades from the view of controlling and monitoring the process:
  - Process Simulators for Steel Grade and Process Development
  - Measurement Systems for Quality Improvement
  - Condition Monitoring Systems for Preventive Maintenance
  - Laboratory tests
- Future prospects
  - Processes in steel are defined and automated on a high level
  - High stability in respect to process parameters
  - Research focus: inline characterization of product parameters
  - Research focus: relationship between product and process parameters

Contact

We focus on achieving the most successful production line for our customers

Take a further step towards future, contact us!

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