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Challenges & Improvised Methods for a Successful Electrical Heat Tracing Design & Engineering on A Mega-Size Project

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Abstract: ***The intent of this paper is to highlight some of the crucial points which allow for a smooth execution of the electrical heat tracing (EHT) design work specifically when majority of EHT design & engineering work is performed by Engineering Contractor. Electrical heat tracing typically comes as the last activity in any of the project as base input documents required are Issued for Construction (IFC) copy of Piping Isometrics, Piping & Instrumentation Diagram (P&IDs) and Piping Line List. It becomes challenging to maintain design consistency where multiple offices are involved in EHT design across multiple areas and widely spread in a plant. Tracking and controlling of design inputs like P&IDs, Piping Isometrics and Piping Line List including subsequent changes throughout the plant design & engineering phase which are important and challenging especially on a mega-size project. This paper highlights some of the critical EHT design challenges such as: design alignment, experienced & subject knowledgeable team, interfaces across multiple groups, power supply design interfaces across various areas, workflow and execution plan, piping & process change tracking and incorporating in EHT design, maintaining quality & design consistency.***

Keywords: Electrical Heat Tracing System Design Execution, Heat Tracing Design Alignment, Heat Tracing Execution Plan, Heat Tracing Design Changes.

I. INTRODUCTION

The intent of this paper is to highlight some of the critical points which allow for a smooth execution of the electrical heat tracing (EHT) design work on a mega-size project. The mega-size project here is referred project having thousands of traced piping isometrics (or heat tracing isometrics). Electrical heat tracing typically comes as the last activity in any of the project as base input documents required are Issued for Construction (IFC) copy of Piping Isometrics, Piping & Instrumentation Diagram (P&IDs) and the Piping Line List. Electrical heat tracing plays an important role in plant operation by preventing freezing, allowing optimal process fluid flow, preventing fluid degradation etc.

It is therefore important that the EHT system is designed in consideration of plant safety, operation, and maintenance to get the optimal result. It becomes challenging to maintain design consistency where multiple offices are involved in EHT design across multiple areas and widely spread in a plant. Tracking and controlling of design inputs such as P&IDs, Piping Isometrics and Piping Line List (including subsequent changes) throughout the plant design & engineering phase is important and challenging, especially on a mega-size project.

This paper highlights some of the key EHT design challenges like design alignment, interfaces across multiple design groups, power distribution design, workflow and execution plan, piping & process change tracking and incorporating in EHT design, maintaining quality & design consistency.

II. EHT DESIGN ALIGNMENT AT THE START OF PROJECT

When majority of EHT design & engineering activities are performed in-house by Engineering Contractor, EHT design alignment across various design groups/offices including EHT supplier(s) is one of the most important activities and should be considered as foundation for a successful EHT design execution on a mega-size project. EHT design alignment includes agreement and alignment on various deliverable Go-by's, governing EHT design input documents (P&IDs, Piping Isometrics, Piping Line List etc.), zoning & grouping of EHT circuits, defining responsibilities for various design activities, "IN/OUT" flow of design deliverables and design consistency. Following are some of the important design alignment points discussed in more detail.

A. Alignment For Governing EHT Design Input Documents

Agreement amongst relevant parties (i.e., Client, EHT supplier, Various Design Offices) on governing document for extracting heat tracing requirements is paramount important to have a common and clear understanding which should be followed for determining the heat tracing requirement and defining the scope extent of electrical heat tracing. Typically, EHT requirement is specified in all documents like P&IDs, Piping Isometrics and Piping Line List, but it has been experienced that there is certain level of discrepancy for EHT requirement between these documents. It becomes important to have a single governing document for all EHT design requirement to be followed and implemented by all. P&IDs are the basic driver for EHT requirement and should be the governing document for EHT design and any discrepancy with Piping Isometric and/or Piping Line List should be resolved as an ongoing activity in detail design phase.

B. Aligning Technical Design Parameters and Materials

Prior to start of EHT detailed design, have an agreement on the various technical parameters which are to be used for the EHT design. This will help to maintain a design consistency amongst the various design groups and avoid any design rework later in the project.

Below are some crucial design points to align on, be documented and shared amongst all design groups:

1) Minimum & maximum ambient temperature for above ground and underground scope pipelines.
2) Piping isometric requirement (hard copy or model file extractions).
3) Heat Traced Instrument List with tubing bundle types, installation details.
4) Mechanical Equipment List to identify heat traced equipment.
5) Hazardous area classification (Zone/Class & Division, Gas Group, T-Rating).
6) Consideration of maximum continuous exposure temperature (Pipe Operating or Design Temperature).
7) Maximum intermittent exposure temperature.
8) Steam out temperature & Upset temperature (as applicable).
9) Basis of thermal insulation material type & thickness along with insulation properties including thermal conductivity (k-value).
10) Heat tracing software to be used along with version.
11) Modularization design philosophy including scope of work & material supply.
12) Zoning & grouping philosophy considering flow/no flow conditions.
13) Heat Tracing Control Method (e.g., Ambient Sensing, Line-Sensing Thermostats, Microprocessor Control Panels)
14) Heat tracing power distribution.
15) High integrity and redundancy requirement (as applicable).
16) Installation details (if any specific other than EHT supplier) for heat tracing.
17) Material with their models/catalogue numbers for heat tracing cables and associated accessories required to be used as heat tracing components are specific to EHT supplier and are not recommended to be mixed for different EHT supplier.
18) Procurement scope for instrument tubing bundles
19) Go-by's or sample template with design content for all design deliverables to be produced.

It has been experienced on some of the projects that the Piping Line List does not state the maximum operating temperature, steam-out requirement, and fluid degradation temperature (if applicable) which could lead to EHT design changes at a later stage. Preparing a design guideline which lists all agreed crucial design points would be helpful in maintaining design consistency and avoiding rework across various design groups and plants/areas.

C. Workflow and Execution Plan

Defining a clear and requirement-based execution plan with detailed responsibility among various design groups is always helpful and should be updated to include any new activities or responsibilities (as required). Depending on the system & software adopted on a project for heat tracing design, there are typical EHT design activities like Piping Isometric extraction, Piping Isometric cleaning/template, EHT calculation, EHT isometric preparation, Material take off (MTO) preparation, modelling, preparation of power distribution deliverables such as: heat tracing zone redlined P&IDs, cable block diagram/wiring diagram, heat tracing distribution board schedule, heat tracing design schedule, heat tracing set point schedule, etc. Execution plan in workflow pattern with detailed listing of responsibilities is effective (easy to refer, understand, indicates work sequence) compared to just listing down in any word/excel file.

D. Design Reference Document and Consistency Checks

While working on a mega-size project with a large team and/or multiple design groups having different level of electrical heat tracing experience/knowledge, it becomes challenging to maintain consistency in design deliverables across various areas/sub plants. Creating a design Go-by reference document which details all crucial design aspects, trainings including refreshers can be helpful for the team members while working and maintaining consistency. Additionally, creating a project specific checklist and implementing (as needed) also helps to maintain design consistency.

III. EHT POWER REQUIREMENT AND DISTRIBUTION

Electrical heat tracing is often widely spread-out including utility lines in addition to plant process lines. It is important to know accurate current & possible future spread of heat tracing scope for pipelines, equipment, and instrument to plan electrical power distribution infrastructure (EHT panel location, transformer sizing, power availability, cable trays with structural support, upstream power cables, alarms/signals etc.). During the Front-End Engineering Design (FEED) stage, all required information for the EHT estimate is rarely available. EHT team should work closely with piping, process, mechanical and control system discipline to have more precise information for tracing scope, temperature requirements and other required parameters prior to the detailed design phase. Due to non-availability of all required design inputs along with the expected detailed design growth, it is recommended to include some level of margin during the FEED stage.

This margin would allow for some increase in electrical load and quantities of the following: EHT panels, heater cables and accessories, power & Resistance Temperature Detector (RTD) cables, cable trays/conduits etc. It is common to have growth in the EHT scope during detailed design which makes a deeper impact not only on electrical infrastructure requirement (in terms of upstream power supply feeder, incoming power cables, cable trays, control & signal cables etc.), but also to other disciplines for the requirement of foundation, cable tray supports, cable trenches, etc. Preparing a load density plan indicating the anticipated location of EHT distribution panels covering the EHT scope areas is helpful as a reference, to account for changes due to re-estimation and in planning of production for power distribution deliverables such as distribution board schedule, cable block diagram/wiring diagrams and layouts.

A. Keep Track of EHT Material, EHT Power and Circuit Requirements / Scope Changes

As piping and process changes are experienced in almost every project (even after issue of IFC Piping Isometrics and P&IDs), perform a re-estimate & impact assessment due to piping & process changes to make any adjustment for EHT impact. This impact may be to: EHT distribution panels, power load requirements, power cables (which could further have cascading impact on upstream transformer/generator), cable trays/routings, civil foundations, and structural supports, etc. Sometimes, it has been experienced that a single change in maintenance temperature (e.g., from 5 deg. C to 80 deg. C) for a large pipe size (e.g., 36 inch) could not only result in increase of heater circuits but can also require additional EHT distribution board(s). Delay in incorporating additional EHT requirements could have a significant impact on heat tracing cost, as well as project schedule.

IV. EHT DESIGN CHANGE MANAGEMENT (PIPING & PROCESS PARAMETERS)

One of the main challenges in EHT design is tracking, assessing, processing, and incorporating continuous piping & process changes throughout the cycle of the project. It becomes highly important that EHT team members are fully aware of the latest piping & process parameters. This is possible with a very close inter-discipline (piping, process, mechanical and control system) co-ordination and support. In the case of a modularization project with on-going fabrication, it becomes crucial that EHT design deliverables are issued with up-to-date piping & process parameters to avoid rework/delay at module yard/fabrication site.

Tracking of piping & process changes are not always easy nor timely managed, so having a dedicated piping team member for supporting the EHT team is recommended for resolving piping queries and control & monitoring of ongoing piping changes (especially on a mega-size project).

A. Specifying Revision of Piping Isometric in EHT Deliverables

Specifying revision of all piping isometric within the EHT Isometric and EHT design schedule is critical to change management. This revision information establishes the basis of the design as shown, and ensures the design is based on the most up-to-date information. This revision is used for assessment of changes made by piping and process and should be considered a required component to the EHT Isometric deliverable.

B. EHT Design Inputs & Deliverable Tracking

Wherever multiple design groups or offices are involved, a close coordination is imperative to ensure a common understanding of updated design input documents (including Piping Isometrics, P&IDs, Piping Line List). There are various methods to maintain a record of all design inputs and issued document, for example:

1) Maintaining a common log of all piping isometric and EHT deliverables which is regularly updated by all responsible design groups.
2) Creating a dashboard with a summary of all inputs and issued deliverables which would help all design groups to have better control, planning and design execution.
3) Maintaining Area-specific activity registers (in excel) detailing all heat traced piping isometrics and EHT isometrics which include information such as: issue dates, revisions, Construction Work Package (CWPs), etc. This will help track the design inputs used for EHT design and allow revisions of piping isometric to be easily identified, assessed, and processed.

Issues can arise when we have thousands of circuits and power boxes tags to be grouped (based on fluid code, winterization or process, start-up current, flow/no flow conditions) or optimized. To reduce no. of circuits and power cables, it is recommended to maintain a common design data log in excel or other tool/software which can record all tags and relevant data (start-up current, operating current, maintenance temp, grouping basis etc.). This will help in preparation and checking of power distribution deliverables and maintain consistency. This is especially true when a large size team is working on various areas and activities/deliverables. It has also been experienced that any exception to power distribution philosophy should be recorded during detailed design phase. This would be helpful in clarifying and providing resolution to site queries.

C. Incorporating Piping & Process Changes in EHT Design

Post-IFC piping changes (e.g., pipe length, pipe size, pipe fittings, routing, thermal insulation) and process changes (e.g., maintenance, operating & design temperature, thermal insulation etc.) occur on every project, and vary in degree of impact to the EHT design. Hence, timely execution of changes in EHT design is important to avoid rework and/or delay construction activities. Redesigning to incorporate all Piping/Process changes for each change might not be a practical approach, as there could be other areas where EHT design might already be in-progress/planned. This has been experienced where last moment changes originated by Piping/Process impacting EHT required immediate attention and redesign to avoid any delay. Delaying in design of any area based on a redesign requirement should be discussed and agreed as per the project schedule. There may be significant impact to the EHT design based on changes to the piping isometrics and/or process parameters. Following are some points to be considered when EHT redesign is required:

1) Project completion schedule requirement, including other design priorities.
2) Availability of EHT design team.
3) Fabrication or Construction work plan.
4) Clarity on forecast for piping & process changes and availability of design input document.
5) Impact assessment should be performed by experienced EHT engineer as there might be small & minor piping changes which impacts EHT design, however these can be incorporated by fabrication/site team during installation and could save on efforts required for revision cycle/time for design deliverables.

A close coordination with Piping & Process is key for effective change management in EHT design, as there might be cases where Piping/Process discipline are making changes, and EHT design is also in-progress for the same scope pipelines/areas in parallel. It becomes difficult at the end of the project, or during installation, when Piping & Process changes are not properly managed in the required time frame.

A snapshot of sample EHT impact assessment execution plan is included below (Attachment-1).

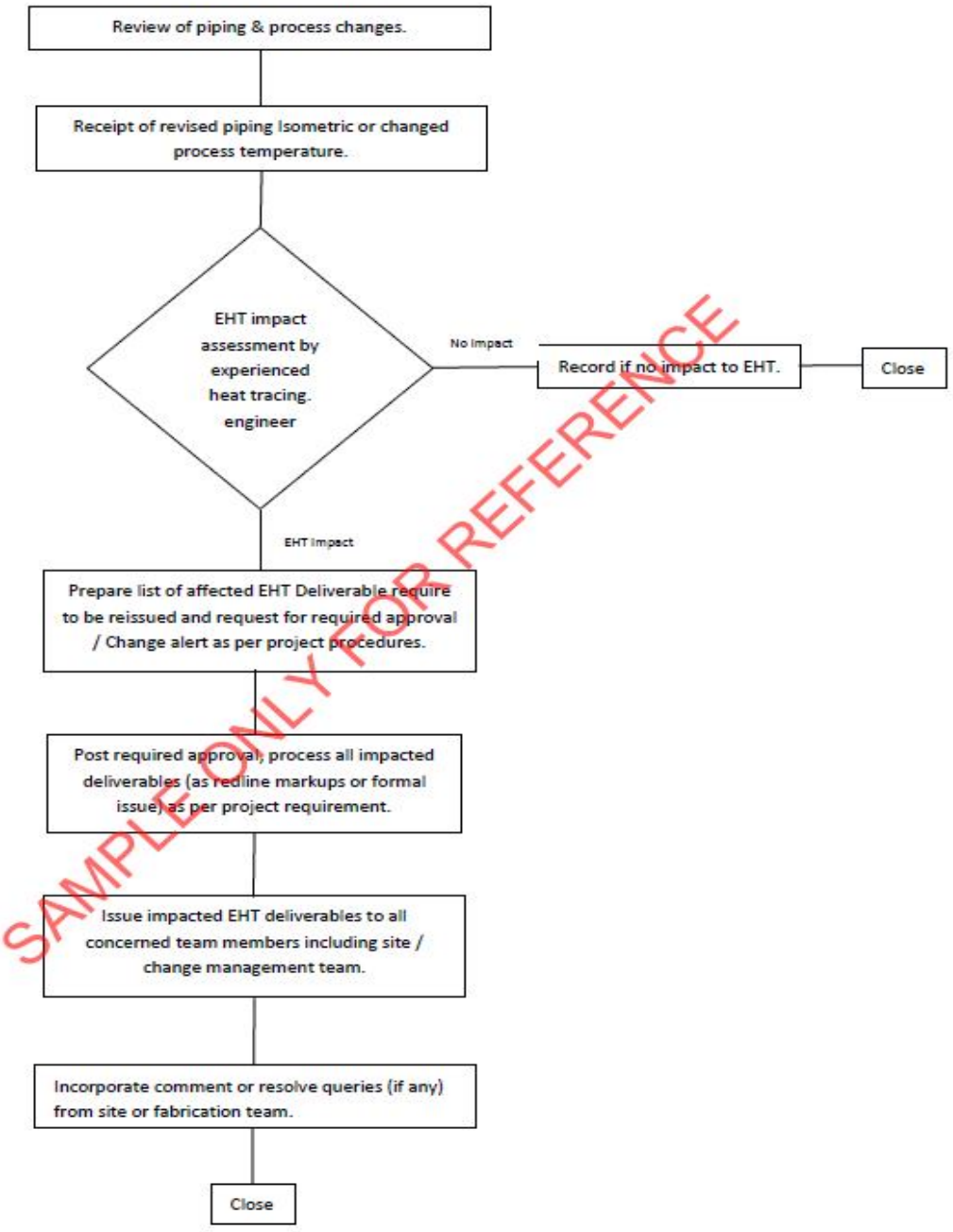
V. SUMMARY

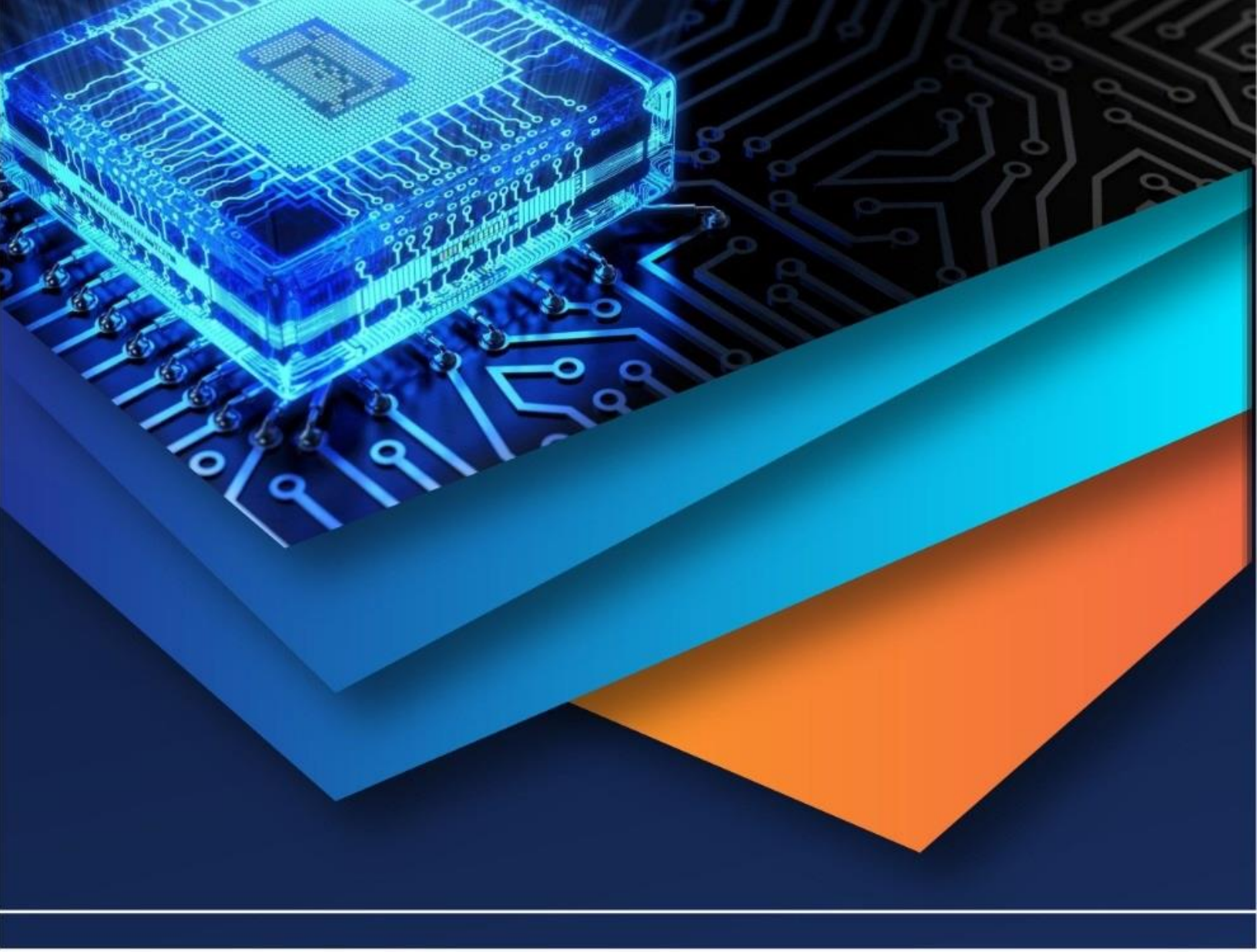
In Summary, electrical heat tracing design success on a mega-size project is reliant on many components including: EHT design alignment, experienced EHT design team, design inputs & deliverables tracking, EHT change management, close coordination with piping, process, mechanical and control system. A poorly managed EHT Change Management Process will result in design-rework, site installation delays, and delay in overall project completion. For example, if Piping Isometric changes post IFC are not incorporated in EHT design, it will lead to rework and/or halt at site as actual piping laid is different to what was considered in EHT isometric for any change in length, pipe diameter or route etc.

When Change Management is not enforced, the resulting designs may be incorrect, which can then have an impact on plant operation. Having experienced and knowledgeable EHT team members, proper tracking of all piping & process changes, and timely implementation of these changes are key to the success of EHT design execution on any mega-size project.

ATTACHMENT-1

SAMPLE EHT IMPACT ASSESSMENT EXECUTION PLAN





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