INTERCOMPARISON OF PRESSURE-TIME METHOD AND CURRENT METERING IN A TYPICAL MID-HEAD HPP

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ABSTRACT

This paper will describe the inter-comparison of two flow measurement methods based on absolutely different physical principles: pressure-time method and current meters method. They were carried out in HPP Enchanet, France during site tests performed in year 2014. Excellent correlation between both the methods (pressure-time and current meters) was achieved (difference approx. 0.2 %).

1 INTRODUCTION

HPP Enchanet is a typical mid head HPP hosting one 30 MW Francis turbine. It is located on the Maronne River in Massif Central (France). Its distinctive feature is a large drawdown: gross head can range between 32 and 62 m in normal operation regime. Since its commissioning in 1962-1964, many refurbishments have been done on the runner to increase the total output. EDF, the leading electricity producer in France, wants to know the current performance of the turbine to improve its exploitation. Company OSC was assigned to carry out the Pressure-Time (PT) flow measurement method and Hydrometrics the Current-Meters (CM) method for two different heads in 2014. Both methods were implemented on site because the international codes do not yet allow the use of a bended section for the PT method.

Figure 1 : Dam and powerhouse Enchanet

2 DESCRIPTION OF ENCHANET HPP

The waterway consists of a short 4 m diameter penstock going through the arch dam and under the electrical substation. The slope part of the penstock is about 27° followed by a horizontal part. The total length of the waterway between the intake and the vertical axis of the turbine is about 51 m. The unit is equipped with a butterfly main inlet valve and a full spiral case.

The longitudinal profile of the power plant is shown in Figure 2, which also indicates the locations of the measurement sections: PT, CM and I. Sections I refer to the index method using pressure drop of the converging pipe just before the inlet valve.

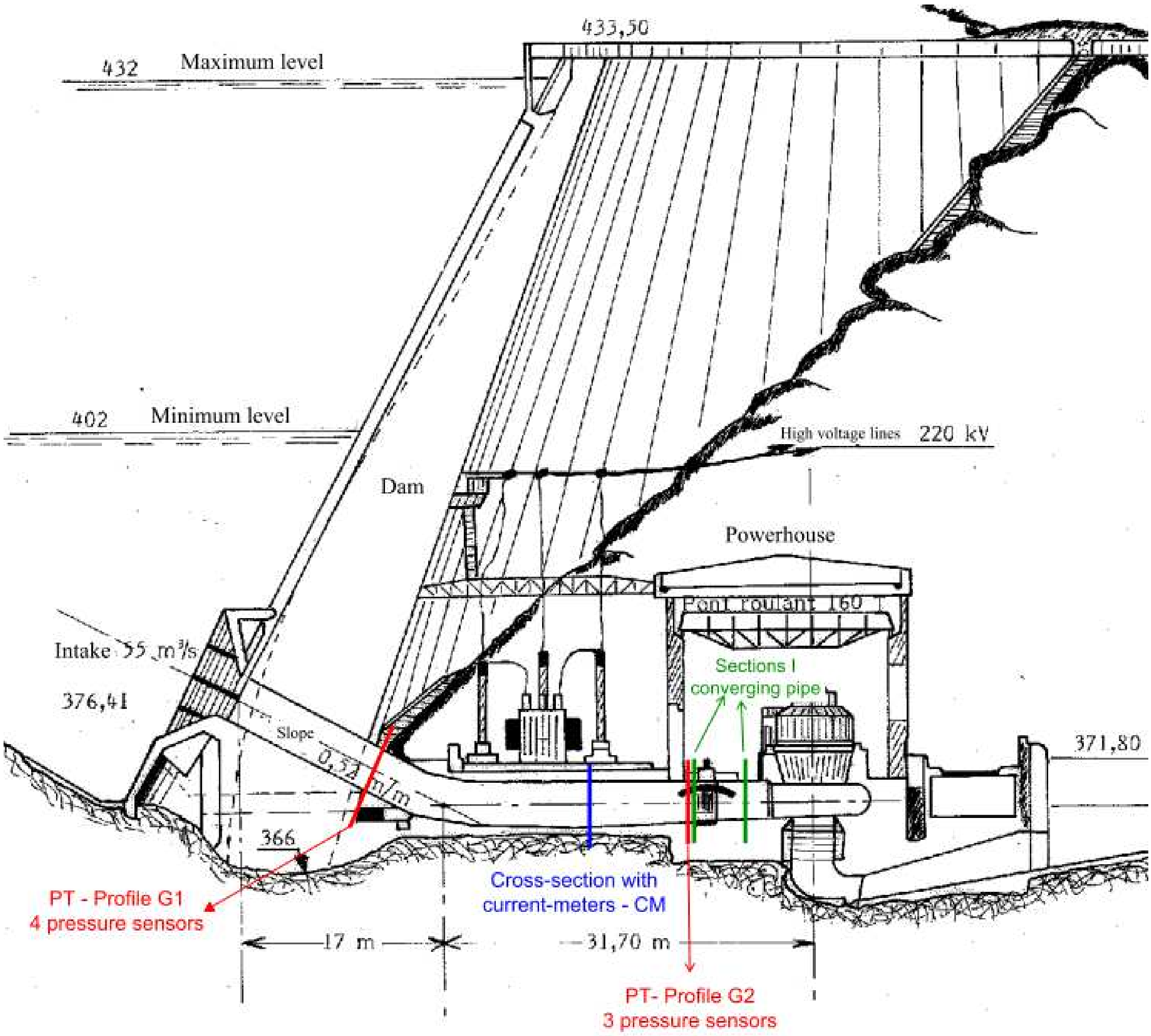

Figure 2 : Penstock longitudinal section with measuring points

3 DESCRIPTION OF THE MEASUREMENT METHODS

3.1 Pressure-time method

Two modes of PT flow measurement were applied at HPP Enchanet: Mode with separate diagrams and also mode with a single diagram.

Instrumentation used:

Not only curved penstock, but also another small imperfection occurred at Enchanet. There were installed only three pressure taps in cross section G2. Pressure taps and piping installation are presented in Figure 3. Both mentioned modes were performed with following valves setup:

Separate diagrams:	red valves OPEN	black valves CLOSED (except of m.p. 132 ÷ 136)
Single diagram:	red valves OPEN	black valves OPEN

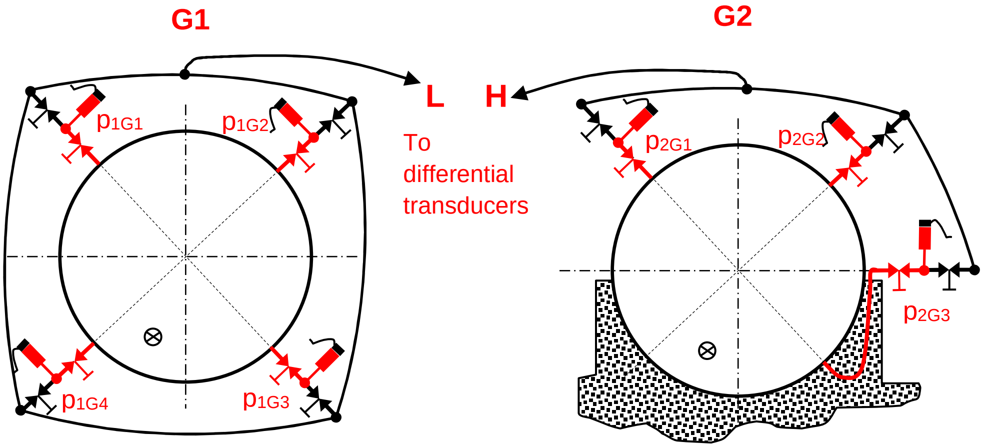

Figure 3 : Location of particular pressure sensors in cross-sections for PT flow measurement

Pressure sensors type BD Sensors DMP331 were used for separate diagrams record. Calibration of whole measuring loops of mentioned sensors was checked using calibrator BEAMEX. Two differential transducers were used for single diagram record. EDF utilized transducer Druck with fast response, OSC used rather slower transducer Rosemount 3051. Both the sensors had small range overlap to negative pressure difference. This fact limited the maximal discharge evaluated by single diagram mode. The cooper pipes ϕ 10 x 1 were used for interconnection of differential transducers with pressure taps.

Software:

NextView from BMCM Company was used for data scanning and basic signals processing. The flow rate calculation was performed using program GibMak. This program is based on mathematical relations described in standard [1]. Offset elimination and integration termination was performed using "engineering approach" as described in [6].

The discharge was parallel evaluated also by EDF own program for PT method.

Penstock factor determination:

Penstock dimensions were exactly measured prior the measurement from inside and also partially from outside of penstock while measured values were compared as well with penstock drawings.

3.2 Current metering

Flow rate measurement by current meters was performed in accordance with standards [1] ÷ [3], using current meters fixed on a special frame installed in closed conduit - see Figure 4. Position of measuring cross-section was chosen in horizontal part of penstock approx. 2D in front of butterfly valve. It was the best position found with respect to real shape of the penstock. Because there wasn't long straight section in front of the frame, relative large number of current meters installed at 6-arm frame was used to determine sufficient number of local velocities in defined points. The frame was designed and checked by modal analyze with respect to minimal vibrations and safe operation by full discharge. Total 37 pcs of current meters Ott each with propellers type R were used for this measurement. All the used current meters were calibrated by authorized laboratory. Duration of one measured point was set to 300 s. Set of special designed counters OSC with total number 40 inputs was used for counting of pulses from current meters.

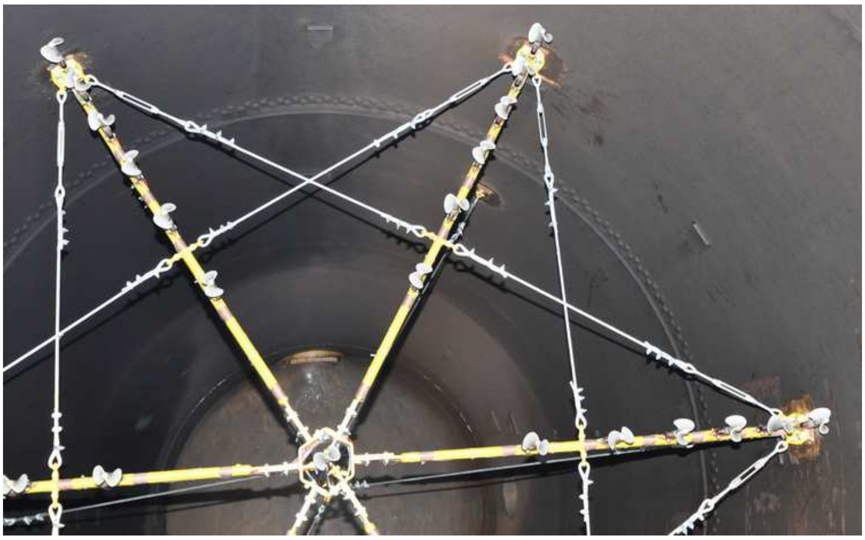

Figure 4 : Front view on the frame with current meters and MIV behind it

Evaluation of scanned data (number of pulses) and calculation of flow rate was performed using program HYDRO11 immediately after finish of each measuring point. Program HYDRO11 is based on valid standards [1] ÷ [3] and includes also corrections on cross-section reduction by measuring device.

3.2 Index flow measurement

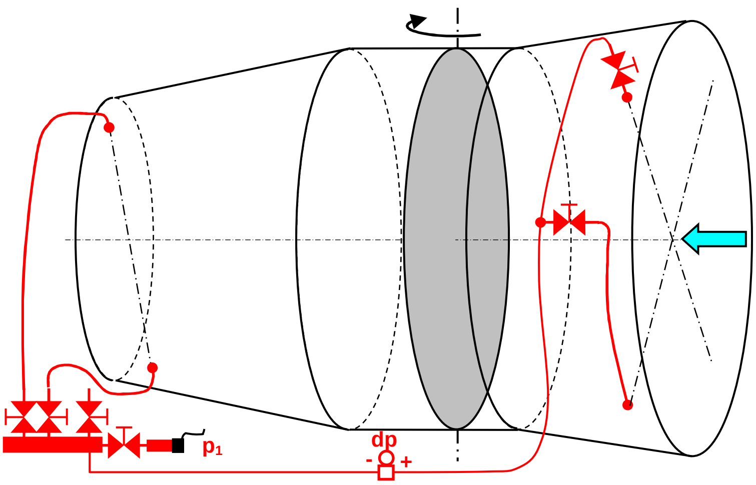

Figure 5 : Layout of pressure taps position in the spiral case inlet

Index flow measurement was also used during the comparative tests because PT and current metering weren't performed at the same moment. Index flow relation Q = f(dp) was used as comparative method for both the primary method. The cone is in front of spiral case as shown in Figure 5. The butterfly valve is placed approx. in midpoint of this cone. This fact together with not totally tight bypass a little bit negatively impacted repeatability of index flow measurement.

4 RESULTS EVALUATION

Flow rate was determined by current meters in all the 14 adjusted points. Uncertainty of this measurement determined in accordance with procedure described in [2] is f_{Qcm} = 1.8 %. Velocity distribution in current meter's profile for Q = 46 m^3/s is then presented in Figure 6.

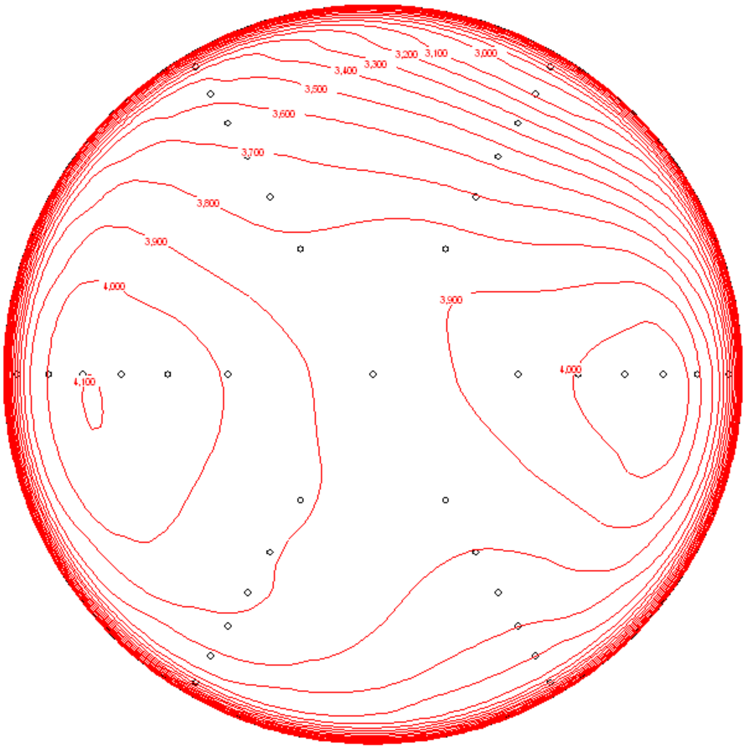

Figure 6 : Velocity distribution in penstock for Q = 46 m^3/s

Total number 7 of unit of shut downs for PT measurement was performed during the tests by higher heads (HH), with uncertainty of PT flow measurement f_{QG} = 1 %.

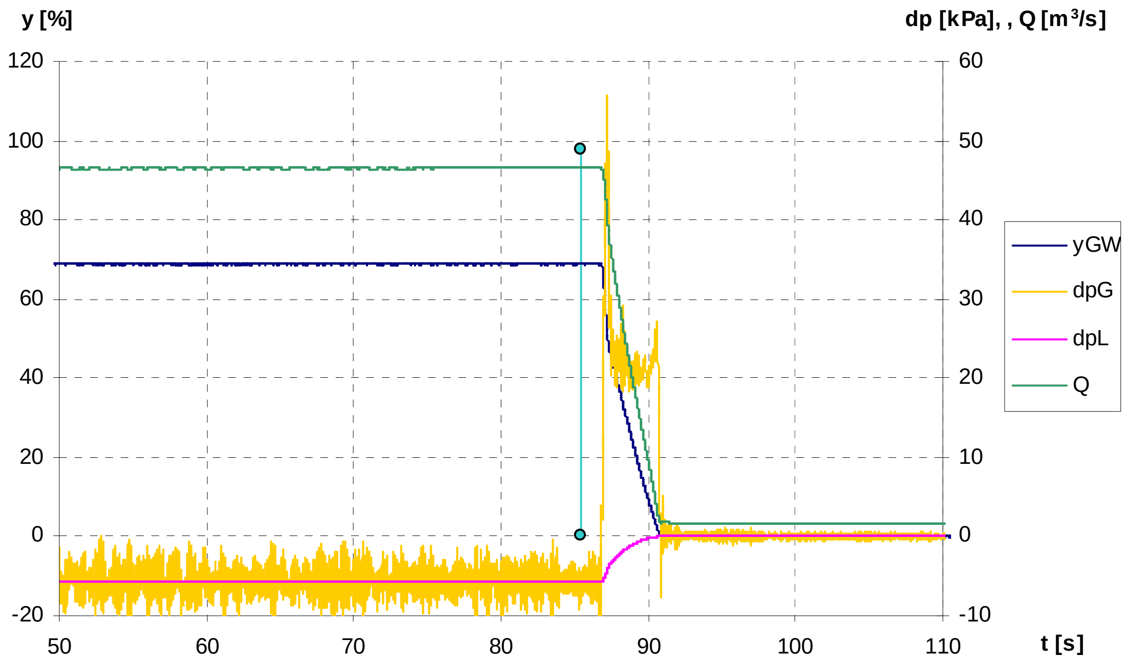

Figure 7 : PT record for Q = 46 m^3/s – main part during guide vane closing

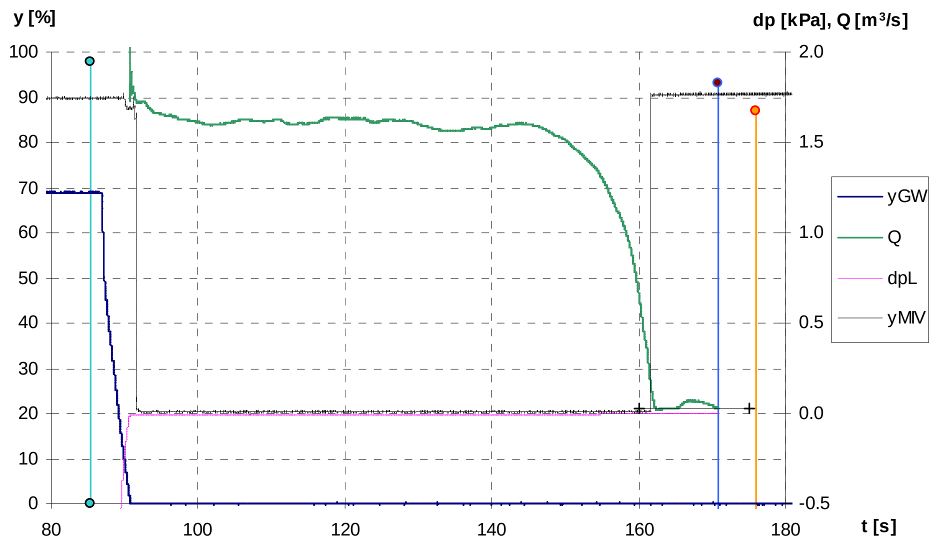

Figure 8 : PT record for Q = 46 m³/s – guide vanes leakage evaluation during MIV closing *)

*) *Main intake valve has only indication of boundary positions OPEN and CLOSE by binary signal.*

Comparison of results obtained by current meters and by PT method is presented in Figure 9. Results of both the methods from the same set of measurement differ an average 0.2% and no more than 0.44%. Measurement by PT method by lover head (LH) performed couple of months later differ from index flow measurement calibrated by current meters by high head on average 0.84% - see Figure 9.

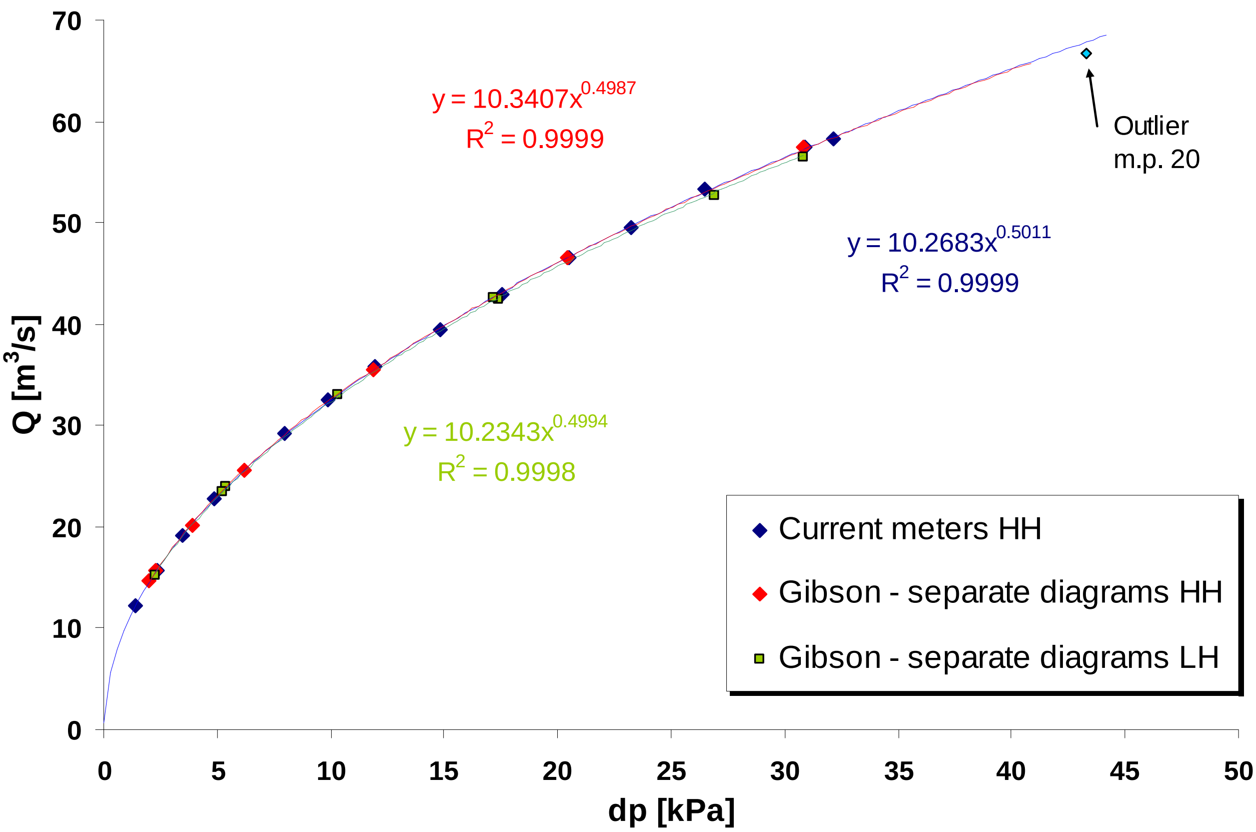

Figure 9 : Comparison of flow rate determined by current meters and PT

Discharge evaluation based on data from fast differential sensor Druck were identical with results based on separate diagrams. Results based on damped signal from differential pressure sensor Rosemount were significant lower (approx. -4%) comparing with other kinds of measurement.

The results of current metering lie very exactly on the approximation curve for index measurement except of the maximum value where are not available any data for explanation whether the reason is streaming around the MIV lens or bad measurement by current meters.

5 CONCLUSION

Good correlation between both the above mentioned results were achieved mainly due of good measurement conditions for PT at Enchanet HPP. Especially important was that the measuring section for PT amounts more than 50% of the total penstock length.

Based on this on-site comparison it is possible to confirm the application of PT method in a smooth bended section as the valid one.

6 REFERENCES

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