Table 2 — Customer Data Requirements for SSR - TDE-Vacuum™ (VOD)

What information is required from the customer?

The implementation level depends on the quality, depth and availability of plant data. The matrix below shows what is typically needed for each TDE-Vacuum™ (VOD) deployment level.

Legend:

● Required ◐ Recommended ○ Optional — Not required

Required input from customer	Offline Simulator	DSS / Advisory Mode	Online Digital Twin
Basic VOD plant data (vessel type, nominal heat size, vacuum system, oxygen blowing equipment, main auxiliaries)	●	●	●
General VOD process description (vacuum treatment philosophy, oxygen blowing logic, decarburization sequence, reduction and trimming practice)	●	●	●
Typical operating values (arrival temperature, initial chemistry, target chemistry, target temperature, treatment duration, vacuum level)	●	●	●
Standard recipes / operating practice	●	●	●
Historical treatment results (final temperature, final chemistry, chromium yield, oxygen used, vacuum performance, alloy additions, slag practice)	◐	●	●
Heat-by-heat / treatment-by-treatment production data	○	●	●
Time-stamped process sequence (vacuum start/end, oxygen blowing phases, inert gas phases if any, alloy additions, sampling events, temperature measurements)	○	◐	●
Actual process measurements during operation	○	●	●
Vacuum pressure data	○	●	●
Oxygen flow data	○	●	●
Inert gas flow data (if applicable)	○	◐	●
Temperature measurement data	◐	●	●
Chemistry and sampling data	◐	●	●
Alloy addition data	○	●	●
Slag practice data (if available)	○	◐	●
Reduction and trimming stage data	○	◐	●

Required input from customer	Offline Simulator	DSS / Advisory Mode	Online Digital Twin
Off-gas data (if available)	○	◐	●
Vacuum system performance data (pump stages, pressure curves, treatment stability, if available)	○	◐	●
Transfer conditions from upstream process (AOD, EAF or LF, if applicable)	○	◐	●
VOD refractory design data (vessel zoning, material grades, nominal thickness)	◐	◐	●
Refractory campaign history and vessel repair records	○	◐	●
Refractory consumption and campaign life records (if available)	○	◐	●
Shell temperature / hot spot history (if available)	○	◐	●
Detailed chromium balance and recovery records by treatment stage (if available)	○	●	●
Slag chemistry history relevant to chromium recovery and refractory attack (if available)	○	◐	●
Reblow, retreatment or corrective trimming history (if available)	○	◐	●
List of available data sources (Excel, CSV, historian, database, Level 2, etc.)	◐	●	●
Live signal availability	—	○	●
PLC / Level 1 / Level 2 tag list	—	○	●
Tag description and engineering units	—	○	●
Data communication architecture (OPC-UA, database, API, historian, network constraints)	—	◐	●
Automation sequence and phase logic	—	○	●
IT / OT environment and deployment constraints	—	○	●
Customer expectations and project objectives	●	●	●

TDE-Vacuum™ (VOD) can start as an Offline Simulator and progressively evolve into DSS / Advisory Mode and a fully integrated Online Digital Twin as plant data availability increases.

Note on data quality and consistency

The quality of TDE™ outputs depends on the accuracy, completeness, time alignment and engineering consistency of the data provided by the customer. Whenever available, data should be supplied with clear units, time stamps, signal descriptions, process phase

references and indication of measurement source. Inaccurate, incomplete or non-synchronized data may still allow a preliminary implementation, but with reduced predictive strength and advisory precision.

Note on chromium-related analyses

Chromium yield assessment, chromium recovery control and decarburization-versus-chromium-loss optimization are significantly improved when chemistry, sampling, alloying, slag and stage-by-stage treatment data are available in a consistent and time-aligned format.

Note on refractory-related analyses

Refractory optimization, lining wear interpretation, campaign life support and slag/refractory interaction assessment can be significantly improved when the customer provides refractory design data, lining zoning, material grades, campaign history, repair records, shell temperature information, hot spot history and refractory consumption records.