California High-Speed Train Project

TECHNICAL MEMORANDUM

Utility Power Supply for Traction Power Supply System
TM 3.1.5.3

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Revision	Date	Description
0	2 Jun 09	Initial Release, voltage and supply redundancy requirements
1	15 Jun 10	Updating of definitions, and addition of conceptual location of utility's HV switching station with respect to traction power substation and its footprints

Note: Signatures apply for the latest technical memorandum revision as noted above.

by PB

for the California High-Speed Rail Authority

System Level Technical and Integration Reviews

The purpose of the review is to ensure:

- Technical consistency and appropriateness
- Check for integration issues and conflicts

System level reviews are required for all technical memorandums. Technical Leads for each subsystem are responsible for completing the reviews in a timely manner and identifying appropriate senior staff to perform the review. Exemption to the System Level technical and integration review by any Subsystem must be approved by the Engineering Manager.

System Level Technical Reviews by Subsystem:

Systems:	NOT REQUIRED Print Name:	DD Month YY Date
Infrastructure:	*Signed document on file* John Chirco	11 Jun 10 Date
Operations:	NOT REQUIRED Print Name:	DD Month YY Date
Maintenance:	NOT REQUIRED Print Name:	DD Month YY Date
Rolling Stock:	NOT REQUIRED Print Name:	DD Month YY Date

Note: Signatures apply for the technical memorandum revision corresponding to revision number in header and as noted on cover.

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ABSTRACT

The California High Speed Train (CHST) Line will be an electrified line with traction power for vehicles being supplied and distributed using a 2 x 25kV 60Hz autotransformer feed type system and an overhead contact system.

Utility power supplies will be required for the 2 x 25kV autotransformer feed type system and for passenger stations, maintenance facilities, train control equipment, communications equipment and other miscellaneous systems, buildings and structures associated with the CHST line.

This Technical Memorandum will only discuss the utility supply requirements for the 2 x 25kV autotransformer feed type system. The utility supply requirements for passenger stations, other facilities and other systems will be discussed in separate memoranda.

The purpose of this Technical Memorandum is to:

- Specify the minimum voltage levels for the 3 Phase 60Hz. utility circuits supplying the traction power substations.
- Specify the requirements for redundant utility supply circuits.
- List the various utility supply companies that serve the CHST Line alignment.
- Provide the Design Manual criteria for the utility supply circuits.

A supplement to this TM will be prepared when information is obtained from the various utility supply companies that will allow the following to be provided:

- Information on various utilities' specific requirements for making connections to the utility's HV supply lines.
- Information on the utility requirements for utility owned equipment in the traction power substations.
- Information on the specific utility requirements for CHST structures and easements necessary to allow connection to the utilities' power supply circuits.
- Information on any power factor correction or harmonic filtering required by the utility companies.
- Information on the utilities' acceptance and/or limitations of energy returned to the utilities' system as a result of regenerative braking by electrically powered rolling stock.

Note:

1. See TM 3.1.1.1 for the Technical Memorandum for the Traction Power 2 x 25kV Autotransformer Feed Type Electrification System.
2. See TM 3.1.1.3 for the Technical Memorandum for Traction Power Facilities General Standardization Requirements.

1.0 INTRODUCTION

There are three (3) items covered in this technical memorandum:

1. The requirement of a minimum voltage level for the utility supply to the traction power substations.
2. The requirement for two (redundant) utility supplies to each traction power substation.
3. General space requirements of the utility companies for their required feeding arrangements.

The following 2 items will be included in the supplement:

1. The specific requirements of the utility companies for their required feeding arrangements and metering of utility supplies, and space requirements for their structures and equipment.
2. The requirements of the utility companies regarding unbalanced loads, regenerated power, and the power factor and harmonic content of connected loads.

1.1 PURPOSE OF THIS TECHNICAL MEMORANDUM (AND ITS SUPPLEMENT)

The purpose of the technical memorandum is to provide the CHST Line requirements for the utility supply circuits supplying the traction power substations. The supplement will detail the specific requirements of the various utility companies when connections are to be made to their supply circuits.

1.2 STATEMENT OF TECHNICAL ISSUE

The following technical issues will be discussed:

1. The minimum acceptable voltage for the supply to the traction power substations.
2. The reason why redundant utility supplies are required.
3. The space requirements for utility owned structures and equipment.

1.3 GENERAL INFORMATION

The CHST Line will have a total route length of approximately 800 miles. It will be designed and built in segments over a number of years. Although the civil and structural elements of the line may vary in the different segments, it is intended that the traction power substation electrical configuration be consistent over the full length of the line. However, utility connection arrangements may vary depending on the requirements of the various utility companies, and the physical layout of equipment may vary due to site variations and constraints.

1.3.1 Definition of Terms

The following terms and acronyms used in this document have specific connotations with regard to this technical memorandum:

Autotransformer (AT): Apparatus which helps to boost the OCS voltage and reduce the running rail return current in the 2 X 25 kV autotransformer feed configuration. It uses a single winding having three terminals. The intermediate terminal located at the midpoint of the winding is connected to the rail and the two outer terminals are connected to the catenary and negative feeder wires.

Easement: A ROW granted to the utility company to allow access to and along the utilities' HV Transmission Lines.

Negative Feeder (NF): Negative feeder is an overhead conductor supported on the same structure as the OCS, and is at a voltage 25 kV with respect to ground but 180^0 out-of-phase with respect to the voltage on the OCS, i.e. the voltage between the OCS and the negative feeder is 50 kV nominal. The negative feeder connects successive feeding points, and is connected to one terminal of an autotransformer in the traction power facilities via a circuit breaker or disconnect switch. At these facilities, the other terminal of the autotransformer is connected to a catenary section or sections, via circuit breakers or disconnects.

Power Transformer: A device which transforms power on an AC system from one voltage level to another (e.g., from 115 kV to 25 kV).

Redundant Utility Supply Circuits: A configuration of two supply circuits from the utility supply company that originate from different transformers or bus systems that minimize the possibility that power to both circuits will be lost simultaneously.

Regenerated Power: Electrical power generated by electric vehicles when they brake by using their electric motors as electric generators.

Traction Power Facilities (TPF): A general term that encompasses substations (SS), switching stations (SWS) and paralleling stations (PS).

Traction Power Supply System (TPS): The railway electrical distribution network used to provide energy to high-speed electric trains, which comprises of the following three types of traction power facilities in addition to connections to the OCS and the traction return and earthing system, including the negative feeders :

1. Substation (SS) at which power is converted from high voltage to a nominal 2X25 kV railway traction voltage and distributed to the Overhead Contact System (OCS) and the negative feeders, including incoming high voltage (115/230 kV) supplies, from power supply utility's network,
2. Switching Station (SWS): An installation at which electrical energy can be supplied to an adjacent but normally separated electrical section during contingency power supply conditions. It also acts as a PS , and
3. Paralleling Station (PS): An installation which helps to boost the OCS voltage and reduce the running rail return current by means of the autotransformer feed configuration. The negative feeders and the catenary conductors are connected to the two outer terminals of the autotransformer winding at this location. OCS sections can be connected in parallel at PS locations.

Unbalanced Loads: Loads applied by a 3 phase transmission line that do not have the same load current across each of the 3 phases

Acronyms:

ac	Alternating Current
AT	Autotransformer
AUTHORITY	California High-Speed Rail Authority
CHST	California High-Speed Train
CHSTP	California High-Speed Train Project
CPUC	California Public Utilities Commission
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
HV	High Voltage
IEEE	Institution of Electrical and Electronic Engineers
LADWP	Los Angeles Department of Water & Power
NF	Negative Feeder
NIST	National Institute of Standards and Technology
OCS	Overhead Contact System
PG&E	Pacific Gas & Electric Company
PS	Paralleling Station (with Autotransformer)
SCE	Southern California Edison
SMUD	Sacramento Municipal Utility District
SS	Traction Power Substation (with HV Utility Supply)
SWS	Switching Station (with Autotransformers)
TES	Traction Electrification System
TPF	Traction Power Facilities
TPS	Traction Power Supply System

1.3.2 Units

The California High-Speed Train Project is based on U.S. Customary Units consistent with guidelines prepared by the California Department of Transportation and defined by the National Institute of Standards and Technology (NIST). U.S. Customary Units are officially used in the United States, and are also known in the U.S. as “English” or “Imperial” units. In order to avoid any confusion, all formal references to units of measure should be made in terms of U.S. Customary Units.

2.0 DEFINITION OF TECHNICAL TOPIC

The following sections contain the design considerations and utility requirements that were assessed in determining the criteria for the utility power supply for the 2 x 25kV autotransformer feed type system for the CHST Line.

2.1 CHSTP DESIGN CONSIDERATIONS

The traction power supply system to be supplied by the utility circuits must meet the following performance criteria:

- There must be no degradation of train performance during single contingency power supply conditions (e.g. the loss of a single utility supply circuit, or single item of equipment such as a HV transformer, autotransformer or circuit breaker), for details refer to TM 3.1.1.1 – 2 X 25 kV Autotransformer System.
- There must be no stranding of trains during a second contingency power supply condition. (e.g. the concurrent loss of any two of the above, in any combination).

In addition, the traction power supply system must be able to provide the following under the ultimate load conditions:

- Nominal System Voltage of 25.0kV
- Maximum Long Term Voltage of 27.5kV
- Maximum Short Term Voltage of 29.0kV
- Minimum Long Term Voltage of 19.0kV
- Minimum Short Term Voltage of 17.5kV

2.2 UTILITY COMPANY SUPPLY REQUIREMENTS

It is anticipated that HV power for traction power supply system for the CHST Line will be obtained from the following utility supply companies:

- Los Angeles Department of Water and Power
- Pacific Gas & Electric Co.
- Southern California Edison
- Sacramento Municipal Utility District
- Anaheim Public Utilities Department

At this time the specific requirements of these utility supply companies are unknown. It is anticipated that the utility companies will have requirements in the following areas:

- The means of making a connection to an existing utility circuit
- Space for, clearances to, and access to, utility owned equipment installed as a part of the utility supply to a CHST Line traction power supply system.
- The effect of unbalanced loads on their circuits.
- The power factor and harmonic content of loads connected to their circuits.
- The regeneration of power and it's injection into their power supply circuits.

The individual utility supply companies will be contacted and their requirements for connections to their HV utility power supply circuits will be obtained and presented in a supplement to this memorandum.

3.0 ASSESSMENT / ANALYSIS

3.1 GENERAL

The requirements of the individual utility companies will be analyzed and compiled into criteria for inclusion in the Design Manual.

3.2 ASSESSMENT

The assessment will be presented in the supplement to this Technical Memorandum.

3.2.1 Analysis

The analysis will be presented in the supplement to this Technical Memorandum.

3.2.2 Applicability to US Standards

The following Standards will be applicable to the Utility Power Supply Circuits:

- National Electrical Code (NEC)
- National Electrical Safety Code (NESC)
- IEEE 80
- CPUC GO 95
- CPUC GO 128

4.0 SUMMARY AND RECOMMENDATIONS

4.1 GENERAL

The development of the requirements for the utility supply for the traction power supply system will include, but not be limited, to the following:

- Utility supply single line diagram.
- Utility supply minimum acceptable voltage level.
- Utility supply voltages suitable for supplying traction power substations.
- Typical arrangements for electrical connections to HV utility circuits (e.g. conductor connections, HV switchgear, termination structures).
- Typical space requirements for utility connection structures
- Typical arrangements for utility owned equipment in traction power substations (e.g. C/Ts, P/Ts, metering.)
- Typical space requirements for power factor correction and harmonic filtering equipment (if required).
- Conditioning requirements for re-generated power (if necessary)
- Any differing requirements of the various utility supply companies that could provide power to the CHST Line.

The following requirements are recommended for the utility supply to the traction power substations for the CHST Line:

1. Minimum utility supply voltage - 115kV 3 phase 60Hz.
2. Acceptable utility supply voltages - 115 and 230kV 3 phase 60Hz.
3. Minimum utility circuit redundancy requirements – Two separate 3 phase circuits, originating from different bus systems, may be carried on same transmission towers.

Different feeding arrangements on the high voltage side may include direct feed from a utility substation or loop-in-loop-out feeding arrangement from its HV transmission network. The specific feeding arrangement at any traction power substation of CHST will depend on site specific conditions, the configuration of the utility company's network at that location and the policies/procedures of the utility company.

The utility company may need to install a high voltage switching station adjacent to the traction power substation location. The space requirements for this utility switching station will depend upon the HV system voltage, the feeding arrangement and the configuration of the utility's network, and will vary from site to site. Typically this utility's switching station will have a footprint of 220' x 160'. This switching station should preferably be located adjacent to the traction power substation. Directive Drawing TM 3.1.5.3 – A presents the footprints of the utility's switching station, its alternative conceptual location with respect to the traction power substation, and the easements required for the HV line connection to the traction power substation.

5.0 SOURCE INFORMATION AND REFERENCES

5.1 GENERAL

Source information for the choice of traction power utility supply requirements for the CHST Line was obtained from the following:

- TM 3.1.1.1: Technical Memorandum for the Traction Power 2 x 25kV Autotransformer Feed Type Electrification System.
- TM 3.1.1.3: Technical Memorandum for Traction Power Facilities General Standardization Requirements
- Existing and proposed European HSR Systems
- Existing and proposed Asian HSR Systems
- Existing US Inter-City and Commuter Rail Systems

Additional information to be presented in the supplements will be obtained from the following utility supply companies:

- Los Angeles Department of Water and Power
- Pacific Gas & Electric Co.
- Southern California Edison
- Sacramento Municipal Utility District
- Anaheim Public Utilities Department

6.0 DESIGN MANUAL CRITERIA

6.1 INFORMATION FOR INCLUSION IN DESIGN MANUAL

1. Minimum utility supply voltage – 115kV 3 phase 60Hz.
2. Acceptable utility supply voltages – 115 and 230kV 3 phase 60Hz.
3. Minimum utility circuit redundancy requirements – Two separate 3 phase circuits, originating from different bus systems, may be carried on same transmission towers.

6.2 ADDITIONAL REQUIREMENTS

1. Typically the utility's switching station shall have a footprint of 220' x 160'. This utility switching station should preferably be located adjacent to the traction power substation. Directive Drawing TM 3.1.5.3 – A presents the footprints of the utility's switching station, its alternative conceptual location with respect to the traction power substation, and the easements required for the HV line connection to the traction power substation.