Engineering Standard

SAES-T-500 31 March, 2004
Central Office (CO) Digital
Telephone Switching Systems

Saudi Aramco DeskTop Standards

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1 Scope

This standard covers mandatory requirements governing planning, engineering design and implementation of Central Office (CO) Digital Telephone Switching Systems.

2 Conflicts and Deviations

Any deviations, providing less than the mandatory requirements of this standard require written waiver approval as per Saudi Aramco Engineering Procedure SAEP-302.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-K-003	*Air Condition System for Communications Buildings*
SAES-K-100	*Saudi Aramco Mechanical (HVAC) Code*
SAES-K-511	*Diesel Engines*
SAES-O-100	*General Requirements, Safety and Security*
SAES-P-100	*Basic Power System Design Criteria*
SAES-P-103	*Direct Current and UPS Systems*
SAES-T-151	*Communication D.C. Power System*
SAES-T-243	*Protection Equipment in Communication Buildings*
SAES-T-435	*Station Protection*
SAES-T-481	*Powered In Plant Communications*
SAES-T-521	*Circuit Measuring Techniques*

SAES-T-795	*Communications Facility Grounding Systems*
SAES-T-887	*Electrical Coordination – Protection at Power Plants and Radio Stations*
SAES-T-903	*Outside Plant Electrical Protection and Grounding*
SAES-T-916	*Telecommunications Building Cable Systems*
SAES-T-920	*Cable Information*
SAES-T-938	*Outside Plant Systems - Design*

Saudi Aramco Materials System Specifications

17-SAMSS-511	*Stationary Storage Batteries*
17-SAMSS-514	*Battery Charger/Rectifier*
17-SAMSS-518	*Diesel Generator*

3.2 Industry Codes and Standards

American National Standards Institute

ANSI/NFPA 70	*National Electric Code, NEC*
ANSI C2	*National Electrical Safety Code*

Department of Communications (Canada)

CSA C108.8	*(CSA: Canadian Standards Association) Radiated Emission Limits*

Federal Communications Commission (U.S.A.)

FCC Part 15	*Radio Frequency Devices – Subparts B and D Radiated Emission Limits, revised 1998 and onward*
FCC Part 68	*Connection of Terminal Equipment to the Telephone Network, revised 1998 & onward*

International Telecommunication Union – Telecommunications Standardization Sector (ITU-T) formerly CCITT (The International Telegraph and Telephone Consultative Committee).

ITU-T Yellow Book Rec. E.410	*International Network Management*
ITU-T G.121	*Loudness Ratings of National Systems*
ITU-T G.704	*Synchronous Frame Structures*

ITU-T G.707	*Synchronous Digital Hierarchy*
ITU-T G.711	*PCM of Voice Frequencies*
ITU-T G.712	*Transmission Performance Characteristics of PCM Channels*
ITU-T G.732	*Characteristics of primary PCM Multiplex Equipment Operating at 2048 kb/s*
ITU-T G.811	*Timing Characteristics of Primary Ref. Clocks*
ITU-T G.821	*Error Performance Forming Part of ISDN*
ITU-T G.822	*Controlled Slip Rate Objectives*
ITU-T G.823	*Control of Jitter & Wander (2048 kb/s)*
ITU-T I-series	*For ISDN General Implementation Plan*
ITU-T I.412	*ISDN User-Network Interfaces (Structures)*
ITU-T I.430	*Basic User-Network Interface–Layer 1*
ITU-T I.431	*Primary User-Network Interface Layer 1*
ITU-T I.440 ***(Published Under Alias # Q.920)***	*ISDN User-Network Interface Data Link General Aspects Layer 2*
ITU-T I.441 ***(Published Under Alias # Q.921)***	*ISDN User-Network Interface Data Link Specification Layer 2*
ITU-T I.450 ***(Published Under Alias # Q.930)***	*ISDN User-Network Interface Layer 3 General Aspects*
ITU-T I.451 ***(Published Under Alias # Q.931)***	*ISDN User-Network Interface Layer 3 Specification for Basic Call Control*
ITU-T Q.440 thru Q.480	*Inter-register Signaling Procedures*
ITU-T Q.544	*Digital Exchange Measurements*
ITU-T Q.552 & Q.553	*Transmission Characteristics (2-w & 4-w)*
ITU-T Q.701 thru Q.707	*Message Transfer Part (MTU)*
ITU-T Q.709	*Hypothetical Signaling Reference Connection*
ITU-T Q.721 thru Q.725	*Telephone User Part (TUP)*
ITU-T Q.921 & Q.931	*ISDN-for PRI Signaling*

ITU-T SS No.1	*Signaling System Number 1*
ITU-T SS R2	*Signaling System R2 (Inter-register Signaling)*
ITU-T SS No.5	*Signaling System Number 5*
ITU-T SS No.6	*Signaling System Number 6 (CCS)*
ITU-T SS No.7	*Signaling System Number 7*
ITU-T X.200 & X.210	*IT/OSI Basic Reference Model*
ITU-T X.25	*LAP.B/D (Link Access Protocol B /D)*

International Standard Organization

ISO 3309 & ISO 4335	*High Level Data Link Control (HLDLC) Standards for Frame Structure and Elements and Procedures*

National Fire Protection Association

NFPA 12A	*Halon 1301 Fire Extinguishing Systems*
NFPA 72E	*Standard on Automatic Fire Detectors*

Underwriters Laboratories, Inc.

UL 924	*Emergency Lighting and Power Equipment*

4 Definitions and Terms

Some of the definitions and terms associated with Central Office (CO) digital telephone switching systems, are defined below:

Abbreviated Dialing: A subscriber can dial a short code which is converted in the originating exchange into a form which will establish connection with the local, national, or international number required.

Alternate Mark Inversion (AMI) signal (bipolar signal): A PCM signal, conveying binary digits, in which successive "marks" (or 1's) are normally of alternative, positive, and negative, polarity but equal in amplitude, and in which "space" (or 0) is of zero amplitude.

Alternate Mark Inversion (AMI) violation (bipolar violation): A "mark" which has the same polarity as the previous "mark" in the transmission of AMI signals.

Amplitude Distortion: Distortion of a transmission signal caused by non-uniform passband attenuation as a function of frequency.

Amplitude Modulation (AM): Modulation in which the amplitude of an alternating current is the characteristic varied.

APSK: Amplitude and phase shift keying, is a form of digital modulation using a combination of both amplitude and phase modulation.

Asynchronous Transmission: A mode of communication characterized by start/stop transmissions with undefined time intervals between transmissions.

Attenuation Distortion: Attenuation distortion is the variation in attenuation (loss) relative to that at 1000 Hz.

Automatic Call Distribution (ACD): A switching system used to distribute automatically and evenly incoming calls to a number of stations on a first-come, first-served basis.

Automatic Number Identification (ANI): A feature required for automatic message accounting in a Central Office (CO) switching system, to identify the calling party's number, even if that party is one of several subscribers on a multi-party line.

Availability: (1) With respect to switching systems: the number of outlets available from a particular inlet. (2) With respect to equipment in general: the percentage of time the equipment is operational.

Baud: A variable unit of data transmission speed (1 baud = 1 bit per second).

Bipolar Coding: *See* Alternate Mark Inversion.

Blocked Calls Cleared (BCC): A service discipline in which unserviceable requests are rejected, by the switching system, without service. Also called Lost Calls Cleared (LCC).

Blocked Calls Held (BCH): A service discipline in which unserviceable requests stay "in the system" without being serviced but having a portion of their desired service time elapse until service begins. Also called Lost Calls Held (LCH).

Busy Hour (of a group of circuits, a group of switches, or an exchange, etc.): The busy hour is the uninterrupted period of 60 minutes of which the traffic is at the maximum.

C-Message Weighting: Selective attenuation of voice-band noise in accordance with the subjective effects as a function of frequency.

Call Congestion: Blocking probability of a trunk group.

Call Forwarding: A customized feature available on switching systems that allows customers to direct all incoming calls to another number.

Call Waiting: Subscriber A whose termination is in the active state associated with a call to subscriber B is given a call waiting indication (CWI) that a caller subscriber C, is attempting to obtain connection. Subscriber A may either: (a) ignore or reject the indication and continue with the existing call; (b) terminate the existing call and answer subscriber C; or (c) hold the existing call and answer subscriber C.

Calling Number Indication: A service whereby the calling subscriber's number can be identified by means of a visual or verbal indication at the called terminal.

CAMA: Centralized Automatic Message Accounting (see also LAMA).

CCIS: Common Channel Interoffice Signaling.

CCS: A measure of traffic intensity expressed as so many hundred call- seconds per hour. 1 CCS = 36 erlangs. (See also **Erlang**).

Central Office (CO): A facility of the communication common carrier, where the switching of telephone calls is performed automatically. A switching telephone system in the public network, or in a large corporation's network.

Centrex Service: The provision to subscribers, by means of a specially equipped public telephone exchange, of services normally available only in PABXs (i.e., internal dialing of PABX type, operator's desk, direct access to the network, direct dialing-in, transfer of calls).

Channel Associated Signaling (CAS): A signaling method in which the signals necessary for the traffic carried by a single channel are transmitted in the channel itself or in a signaling channel permanently associated with it.

Channel Bank: Terminal equipment for a transmission system used to multiplex individual channels, by using FDM or TDM techniques.

Circuit: In telephony, sound is carried over an electrical circuit from a calling party through a communication office, where it is switched out to the called party.

Circuit Switching: The principle of establishing an end-to-end connection between users of a network. The associated facilities are dedicated to the particular connection and held for the duration of the call.

Class 5 Office: A category of Central Office (CO) that serves as the network entry point, for user access lines (trunks). Also called "end office".

Clock: Equipment providing a time base used in a transmission system to control the timing of certain functions such as the control of the duration of signal elements, and the sampling. (See also "Master Clock").

Codec: An assembly comprising an encoder and a decoder in the same equipment.

Coherent Demodulation: Demodulation using a carrier reference that is synchronized in frequency and phase to the carrier used in the modulation process.

Common Channel Signaling (CCS): A signaling method using a link common to a number of channels for the transmission of signals necessary for the traffic by way of these channels.

Common Control: A form of automatic control for a switching system that concentrates all control functions into one or more equipment modules shared by all connections.

Companding: The process of compressing a signal at the source and expanding it at the destination to maintain a given end-to-end dynamic range while reducing the dynamic range between the compressor and expander.

Concentration: The process of switching some number of lightly used channels or sources onto a smaller number of more heavily used channels.

Conference Call: A telephone call between more than two participants.

Crosstalk: Crosstalk is the disturbance (specifically speech disturbance) and unwanted signal transfer from one circuit into another. Intelligible crosstalk occurs when some of the words in a conversation can be understood by a person using another circuit. Intelligible crosstalk is objectionable because it interferes with privacy.

dBm: The power level in decibels relative to 1 milliwatt (mW). The standard zero (0) dBm, which has been established in telephony, results from 1 mW of power at a frequency of 1004 Hz across an impedance of 600 ohms.

dBrn: A value of decibels above reference noise that begins at a zero (0) level dBrn. Reference noise is that magnitude of circuit noise, which will produce a reading on a circuit noise meter equal to one picowatt (10^{-12} watts) of electric power at 1004 Hz. Thus: 0 dBrn = 10^{-12} watts = 10^{-9} milliwatts = -90 dBm.

dBrnC: The power level of noise with C-message weighting expressed in decibels relative to reference noise. Reference noise power is –90 dBm at 1004 Hz (-90 dBm = 10^{-12} watts = 10^{-9} milliwatts = 0 dBrn).

dBrnC0: The noise power measured in dBrnC, but referenced to the zero –level transmission level point.

DDD: Direct Distance Dialing. (See also under **Direct Distance Dialing**).

Dial Tone Delay: The time elapsed from off-hook of a telephone set to the initiation of dial tone.

Decibel (dB): The decibel is the standard unit for expressing transmission gain or loss and relative power ratios. The decibel is one tenth (1/10) the size of a Bel, which is a very large unit for convenient use. Both units are expressed in terms of the logarithm to the base 10 of a power ratio. The decibel is expressed mathematically as:

$$dB = 10 \log (P1)/(P2)$$ (Where P1 and P2 are the power levels compared).

Delay Distortion: Distortion is an unfaithful reproduction of signals due to changes occurring in the waveform of the original signal. Delay distortion is the delay at one frequency relative to that at another frequency. In a telephone channel, the reference frequency is often taken as 1700 or 1800 Hz. In any channel the reference frequency may be taken as the frequency of minimum delay.

Digital Signal: A signal constrained to have a discontinuous characteristic in time and a set of permitted discrete values.

Digital Switching: A process in which connections are established by operations on digital signals without converting them to analogue signals.

Direct Distance Dialing (DDD): A method of making long distance (national) toll telephone calls automatically on the public switched telephone network by entering the final destination code through the originating stations telephone set dial.

Direct Inward Dialing (DID): Calls can be dialed from a telephone connected to the local exchange (public network) directly to extensions on a PABX.

Direct Outward Dialing (DOD): Calls can be dialed from a telephone connected to the PABX directly to a local exchange (public network).

DTE: Data Terminal Equipment.

Dual Tone Multi Frequency (DTMF) signaling: Generic name for push-button telephone signaling equivalent to the Bell System's TOUCH-TONE®

Dynamic Range: The range of power levels (minimum to maximum) achievable by a signal or specified for equipment operation.

Echo: A wave that has been reflected or returned with sufficient magnitude and delay to be perceived. (Echo in telephone systems is the return of a talker's voice).

Echo Canceller: A device that removes talker echo in the return branch of a four-wire circuit by subtracting out a delayed version of the signal transmitted in the forward path.

Echo Return Loss (ERL): A measure of the difference in level between the echo returned and the original signal for frequencies between 500 Hz and 2500 Hz. Singing Return Loss (SRL) is a measure of the difference in level between the echo returned and the original signal for frequencies between 200 Hz and 500 Hz and between 2500 Hz and 3000 Hz. Poor return loss causes singing or near singing of amplifiers as well as echoes which can be objectionable if the magnitude is high enough and the delay long enough. (See also "Singing Return Loss").

Echo Suppressor: A voice-operated device placed in the four-wire portion of a circuit and used for inserting loss in the echo path to suppress echo.

Elastic Store: A storage buffer designed to accept data under one clock but deliver it under another, so sort term instabilities (jitter) in either clock can be accommodated.

Electronic Switching System (ESS): Designation of stored program control switching machines manufactured by Lucent Technologies.

End Office: Class 5 switching office. Also referred to as a central office.

Envelope Delay: Derivative of channel phase response with respect to frequency. Ideally, the phase response should be linear, indicating that all frequencies are delayed equally (rate of change of phase versus frequency). Envelope Delay Distortion (EDD) is the maximum difference or deviation of envelope delay between any two specified frequencies.

Equalization: The practice of compensating for transmission distortions with fixed or adaptive circuitry.

Erlang: A measure of traffic intensity, expressed as so many hundred (Century) Call Seconds per hour (CCS). **1 CCS = 36 erlangs** (1 hour = 3600 seconds). Basically, erlang is a measure of the utilization of a resource (i.e., the average number of busy circuits in a trunk group, or the ratio of time an individual circuit is busy). (See **CCS**).

Exchange Area: A contiguous area of service defined for administrative purposes that typically comprises an entire town or city and includes the immediate countryside and suburbs. An exchange area may have one end office or many end offices interconnected by trunks and tandem offices.

Expansion: The switching of a number of input channels onto a larger number of output channels. (Increasing the exchange's capacity with respect to the number of lines and trunks).

Facsimile: The black and white reproduction of a document or a picture transmitted over a telephone connection.

Foreign Exchange (FX) Circuit: An extension of service from one switching office to a subscriber normally serviced by a different switching office.

Four-Wire Circuit: A circuit using two separate channels for each direction of transmission. When wire-line transmission is involved, each direction's transmission, is provided by a separate pair of wires.

Frame: A set of consecutive digit time slots in which the position of each digit time slot can be identified by reference to a frame alignment signal. The frame alignment signal does not necessarily occur, in whole or in part, in each frame.

Frame Alignment: The state in which the frame of the receiving equipment is correctly phased with respect to that of the received signal.

Frequency: Frequency is measured in units called Hertz (Hz). One Hz is one cycle per second.

Frequency Diversity: In radio systems the use of one or more back up transmitters, channels, and receivers to protect against atmospheric (multipath) fading.

Frequency Shift Keying (FSK): Digital modulation using discrete frequencies (tones) to represent discrete symbols.

Full-Duplex Transmission: Transmission in both directions, simultaneously.

Full-Echo Suppressor: An echo suppressor in which the speech signals on either path control the suppression loss in the other path.

Glare: Simultaneous seizure of both ends of a two-way trunks.

Half-Duplex Transmission: Transmission in both directions, but only in one direction at a time.

Half-Echo Suppressor: An echo suppressor in which the speech signals of one path control the suppression loss in the other path but in which this action is not reciprocal. Half-echo suppressors are normally used in pairs-one at each end of the long-distance circuit.

HDB3 (High Density Bipolar 3): A modified AMI (bipolar) line code in which strings of four zeros are encoded with an AMI violation in the last bit. (Since this coding format precludes strings of zeros greater than three (3), it is referred to as **HDB3** coding).

Highway: A common path or a set of parallel paths over which signals from a plurality of channels pass with separation achieved by time division.

Hook Flash: A momentary depression of the hook switch to alert an operator or equipment, but not so long as to be interpreter as a disconnect.

Hot Standby: Redundant equipment kept in an operational mode as backup for primary equipment. Automatic switching to the standby equipment occurs when the primary equipment fails.

Hybrid: A devise used to connect a two-wire, bi-directional circuit to a four-wire circuit.

Idle Character: A control character that is sent when there is no information to be sent.

Impulse Noise: Impulse noise is any burst of noise that produces a voltage of more than 12 dB above the steady state noise, and is typically of 5 microseconds duration. Sources of impulse noise include lightning surges, switching transients and surges on power lines, which induce surges in telephone circuits.

In-Band Signaling: Signaling transmitted within the same channel and band of frequencies used for the message traffic.

Insertion Loss: The transmission loss caused by inserting a component or network in a circuit. The ratio of power received at a load before insertion to that power received at a load after insertion, expressed in decibels.

Integrated Digital Network: A network in which connections established by digital switching are used for the transmission of digital signals.

Integrated Services Digital Network (ISDN): An integrated digital network in which the same digital switches and digital paths are used to establish connections for different services, for example, digital voice, high-speed data (both circuit and packet switched), slow-scan video, etc.

Intercept: Calls which, for reasons such as those listed below, cannot reach the wanted number may be intercepted and diverted to an operator, an answering machine, or a tone (announcement) to give the caller appropriate information. *(a)* Change of a particular number including advice of new number. *(b)* Renumbering of a group of numbers or a change of dialing code. *(c)* Wrong information in telephone directory. *(d)* Dialing of an unallocated code. *(e)* Dialing of a number or numbers allowed by the numbering plan but not yet allocated or no longer in service. *(f)* Rout(s) out of order. *(g)* Route(s) congested. *(h)* Subscriber's line temporarily out of order. *(i)* Suspension of service owing to nonpayment.

International Direct Distance Dialing (IDDD): See Direct Distance Dialing (DDD).

Isochronous: A signal is isochronous if the time interval separating any two significant instants is theoretically equal to the unit interval or to a multiple of the unit interval. *Note:* In practice, variations in the time intervals are constrained within specified limits.

Jitter: Short-term variations of the significant instants of a digital signal from their ideal positions in time.

Junctor: A connecting circuit between switching stages or frames of a single switching office. A junctor may also provide signaling supervision and talking battery for connected subscriber instruments.

Key Telephone Set: A telephone set with special buttons (keys) to provide such capabilities as switching between lines, call holding, or alerting of other telephones.

LAMA: Local Automatic Message Accounting (see also CAMA).

Line Code: A code chosen to suit the transmission medium and giving the equivalence between a set of digits generated in a terminal or other processing equipment and the pulses chosen to represent that set of digits for line transmission.

Local Central Office (CO): A central office (CO) which normally provides service to nearby subscribers and which serves as a termination point for leased trunks.

Local Exchange: A switching exchange serving no more than 10,000 subscribers. The term is often used to refer to the building, which houses the central office (CO) equipment.

Loop Resistance: The actual DC resistance of the circuit. Loop resistance must be specified if it includes the telephone set(s). (The loop resistance associated with cables must also be specified if it includes only resistance of cable and load coils).

Lost Calls Cleared (LCC): A mode of operation in which blocked calls are rejected by the network and may or may not return. (See also "Blocked Calls Cleared" (BCC)).

Lost Calls Held (LCH): A mode of operation that holds blocked call requests until a channel becomes available. The portion of call that gets blocked is lost. (See also "Blocked Calls Held" (BCH)).

Main Distribution Frame (MDF): A Central Office (CO) structure with wiring terminations to connect the switching equipment with the outside cables. Connections are made between points on the frame by jumper wires, which can be readily changed.

Master Clock: A clock, which generates accurate timing signals for the control of other clocks and possibly other equipment. (See also "Clock").

Message switching: The practice of transporting complete messages from a source to a destination in non real time and without interaction between source and destination, usually in a store-and-forward fashion.

Modem: A contraction of the terms modulation and demodulation. A device used to generate "voice-like" data signals for transmission over telephone lines. A modem is referred to as a "data set" in Bell System terminology.

Modified Alternate Mark Inversion: An AMI signal that does not strictly conform with alternate mark inversion but includes violations in accordance with a defined set of rules. Examples of such signals are HDB (high-density binary), B6ZS, and B3ZS.

Multi Frequency (MF) Signaling: A signaling method used for interoffice applications. MF signaling uses two of six possible tones to encode 10 digits and five special auxiliary signals.

Multiplexing: The process of combining multiple signals into a single channel for transmission over common facilities.

Near-End Cross-Talk (NEXT): Unwanted energy coupled from a transmitter in one circuit into a receiver of another circuit at the same location (near end).

Network: Network is a physical structure of paths or channels over which information can be moved.

Network Management: Network management is the function of supervising a communications network to ensure maximum utilization of the network under all conditions. Supervision requires monitoring, measuring and, when necessary, action to control the flow of traffic. The objective of network management is to provide service protection and to maximize the number of paid conversations by fully utilizing available equipment and facilities during normal and abnormal periods.

Non-Blocking: A switching network that always has a free path from any idle incoming trunk or line to any idle outgoing trunk or line.

Non-Return to Zero (NRZ): A line code that switches directly from one level to another. Each level is held for the duration of a signal interval.

Objectives: Objectives are the recommended operating limits for circuits or equipment in order to keep overall performance at a desired level.

Off Hook: The state or condition that a telephone receiver is requesting service, or it is in use. A supervisory signal is also associated with the off hook condition, indicating active status of a telephone or line.

Offered Traffic: It is necessary to distinguish between traffic offered and traffic carried. The traffic carried is only equal to the traffic offered if all calls are immediately handled (by the group of circuits or group of switches being measured) without any call being lost or delayed on account of congestion. The flow of traffic offered, and of traffic carried, is expressed in erlangs. The amount of traffic offered and of traffic carried is expressed in erlang-hours.

On Hook: The inactive status of a telephone or line.

One-Way Trunk: A trunk circuit that can be seized at only one end.

Out-Of-Frame Alignment Time: The time during which frame alignment is effectively lost. That time will include the time to detect loss of frame alignment and the alignment recovery time.

PABX (Private Automatic Branch Exchange (also a PBX): Switching equipment used by a company or organization to provide in-house switching and access to the public network.

Packet-Mode Operation: The transmission of data by means of addressed packets whereby a transmission channel is occupied for the duration of transmission of the packet only. The channel is then available for use by packets being transferred between different data terminal equipment.

Pair-Gain system: A subscriber transmission system that serves a number of subscribers with a smaller number of wire pairs, by using concentration, multiplexing, or both.

Parity: The process of adding a redundant bit to a group of information bits to maintain either odd or even numbers of 1's in the composite group of bits. A parity error results if an odd number of 1's is detected when even parity is transmitted or vice versa.

Phase Distortion: Signal distortion resulting from nonuniform delay of frequencies within the passband.

Phase Jitter: The unwanted change in phase or frequency of a transmitted signal caused by modulation by another signal during transmission.

Phase Shift Keying (PSK): A form of digital modulation that uses 2^n distinct phases to represent *n* bits of information in each signal interval.

Plesiochronous: Two signals are plesiochronous if their corresponding significant instants occur at nominally the same rate, any variation in rate being constrained within specified limits. *Notes:* (1) Two signals having the same nominal digit rate, but not

stemming from the same clock are usually plesiochronous. (2) There is no limit to the phase relationship between corresponding significant instants.

PBX (Private Branch Exchange): Switching equipment used by a company or organization to provide in-house switching and access to the public network.

Post-dial Delay: Is the amount of time it takes after the calling subscriber completes dialing until ring-back tone is received.

Protection Switching: That category of restoration in which one transmission path is substituted for another to permit maintenance operations for the protection against component failure, or remedy temporary conditions such as fading. This is intended to reflect a configuration in which *M* paths protect *N* paths on the same route.

Psophometric Weighting: Noise weighting filter recommended by CCIR.

PSTN: Public Switched Telephone Network.

Pulse Amplitude Modulation (PAM): The process of representing a continuous analog waveform with a series of discrete time samples. The amplitudes of the samples are continuous and therefore analog in nature.

Pulse Code Modulation (PCM): A process in which a signal is sampled, and the magnitude of each sample with respect to a fixed reference is quantized and converted by coding to a digital signal.

QPRS: Quaternary channel modulation using partial response signaling on each channel.

QPSK: Quaternary phase shift keying (4-PSK).

Quadrature Amplitude Modulation (QAM): Independent amplitude modulation of two orthogonal channels using the same carrier frequency.

Quantization Noise: The difference between the discrete sample value represented by a digital code and the original analog sample value.

Quantizing: A process in which samples are classified into a number of adjacent intervals, each interval being represented by a single value called the quantizing value.

Reference Clock: A clock of high stability and accuracy which is used to govern the frequency of a network of mutually synchronizing clocks of lower stability. The failure of such a clock does not cause loss of synchronization.

Reframing Time: The time that elapses between a valid frame alignment signal being available at the received terminal equipment and frame alignment being established.

Regeneration: The process of recognizing and reconstructing a digital signal so that the amplitude, waveform, and timing are constrained within stated limits.

Regenerative Repeater: A device used to detect, amplify, reshape, and retransmit a digital bit stream.

Resistance: Property of a conductor that determines the current, which will flow through it, when a particular voltage is applied. In electrical circuit, the greater the resistance between two points the greater the drop in voltage.

Return Loss: The difference in dB between reflected and incident energy at a signal reflection point. (See also "Echo Return Loss" and "Singing Return Loss").

Ringback: The signaling tone returned by switching equipment to a caller, indicating that a called party telephone is being alerted (ringing).

Sidetone: The portion of a talker's signal that is purposely fed back to the earpiece so that the talker hears his or her own speech.

Signaling: The exchange of electrical information (other than by speech) specifically concerned with the establishment and control of connections and management in a communication network.

Significant instants: The instants at which a digital line code changes state. (The boundaries of a signal interval).

Simplex Transmission: A mode of operation involving transmission in one direction only.

Singing: An audible oscillation of a telephone circuit caused by a net amount of gain in a four-wire segment of the circuit.

Singing Return Loss (SRL): A loss due to impedance mismatch particularly at the junctions between interconnected circuits. (For more details see also "Echo Return Loss").

SLIC: Subscriber Line Interface Circuit.

Slip: At the interface between two digital systems, slip is the insertion or deletion of data into or from the data stream caused by an offset in clock frequencies.

Space Diversity: In radio systems, the use of two receiving antennas and possibly two separate receivers to provide protection against atmosphere included signal attenuation (fading).

Span Line: A repeated T1/E1 line from end to end but not including channel banks.

Speech Digit Dialing (robbed digit signaling): Signaling in which digit time slots, primarily used for the transmission of encoded speech, are periodically used for signaling.

Speech Dialing: The use of a short address code to represent an often-called telephone number. The common control computer in a PABX or end office switching system, providing such a service, translates the short code into the desired number.

Star Network: A network with a single node to which all other nodes are connected.

State Store: A memory map of the connection status of a switching matrix.

STS: Space-Time-Space digital switching structure.

Stuffing Character: A character used on isochronous transmission links to take account of differences in clock frequencies.

Supervisory Signal: A signal used to indicate the status of a line or to control equipment on the line.

Synchronous: Two signals are synchronous if their corresponding significant instants have a desired phase relationship.

Synchronous Network: A network in which the clocks are controlled so as to run, ideally, at identical rates, or at the same mean rate with limited relative phase displacement.

Synchronous Transmission: A mode of digital transmission in which discrete signal elements (symbols) are transmitted at a fixed and continuous rate.

Talkoff: An inadvertent disconnect caused by speech sounds being interpreted as in-channel control signals (disconnects).

Tandem Office: In general, any intermediate switch used to establish a connection. In specific terminology, a tandem office is a switch used to interconnect end offices in an exchange area.

TASI: Time Assignment Speech Interpolation, is the practice of concentrating a group of voice signals, onto a smaller group of channels, by dynamically switching active voice signals to idle channels.

Ternary Coding: The use of all states of a three-level code to send more than one bit of information in a single symbol. This is in contrast to bipolar coding, which uses three levels, but only one of two in any particular interval. One method of interfacing binary data to a ternary line code is to encode 4 bits with three ternary symbols (4B-3T).

Tie Line: A dedicated circuit connecting two private branch exchanges.

Time Congestion: The ratio of time that all facilities of a system are busy (congested). Time congestion refers to the status of the system and does not necessarily imply that blocking occurs.

Time Division Multiplexing (TDM): TDM is sharing a transmission link among multiple users by assigning time intervals to individual users during which they have the entire bandwidth of system.

Time Expansion: The use of more time slots on internal links of a switch than exist on external links.

Time Out: A network parameter related to an enforced event designed to occur at the conclusion of a predetermined elapsed time.

Tip And Ring Conductors: The two conductors associated with a 2-wire cable pair. The terms tip and ring deliver their names from the physical characteristics of an operator's cord-board plug, in which these two conductors terminated in the days of manual switchboards.

Tip Cable: A small (usually 100-pair) cable connecting terminals on a distributing frame to cable pairs in the cable vault.

Toll: The charge of making calls outside the boundaries of an exchange. Also a general term applied to the facilities and services of carriers used in conjunction with making toll (long distance) calls.

Toll Center: A switching center in the Bell System hierarchy of exchange classes. The toll center is a class four (4) exchange. It is used to connect end offices to long distance (toll) circuits. It can be used to establish connections with other central offices to increase routing options.

Traffic Carried: The amount of traffic carried (by a group of circuits or a group of switches) during any period, is the sum of the holding times expressed in hours.

Traffic Flow: The traffic flow (on a group of circuits or a group of switches) equals the amount of traffic divided by the duration of the observation, provided that the period of observation and the holding times are expressed in the same time units. Traffic flow calculated in this way is expressed in erlangs.

Transhybrid Loss: The amount of isolation (in decibels) between go and return paths on the four-wire side of a four-wire to two-wire hubrid.

Transmission Level Point (TLP): A specification, in decibels, of the signal power at a point in a transmission system relative to the power of the same signal at a zero transmission level point (0 dB-TLP).

Transmission Reference Point (TLP): A hypothetical point used as the zero relative level point in the computation of nominal relative levels.

Transmultiplexer (Trunsmux): A type of equipment that transforms signals derived from frequency-division-multiplexed equipment (such as group or super-group) to time-division-division-multiplexed signals having the same structure as those derived from PCM multiplex equipment (such as primary or secondary PCM multiplex signals) and vice versa.

Trunk: A circuit or channel between two switching systems.

TST: Time-Space-Time digital switching structure.

Two-Wire Circuit: Is a circuit consisting of a single pair of wires and capable of simultaneously carrying two signals in opposite directions.

Two-Way Trunk: A trunk circuit that can be seized at either end of the circuit.

Unipolar: A binary line code using single polarity pulses and zero voltage for the two coding levels.

Virtual Call (Circuit): A user facility in which a call setup procedure and a call clearing procedure will determine a period of communication between two DTEs in which the user's data will be transferred in the network in the packet mode of operation. All the user's data are delivered from the network in the same order in which they are received by the network.

Voice Frequency Bandwidth: The human voice is capable of producing sound of various tones. In telephony, the normal voice frequency band is from 300 Hz to 3400 Hz.

Wait on "Busy": A subscriber making a call to a busy number holds the call and is connected when the number is free.

Wide Area Telephone Service (WATS): For a flat-rate a subscribed area from a particular telephone termination is charged without the registration of call charges.

Waiting Time Jitter: Arrival time jitter in a digital signal produced by pulse stuffing operations and occurring because timing adjustments must wait for predefined time slots to occur.

5 Design Requirements

5.1 All Central Office (CO) Digital Telephone Switching Systems and associated equipment that are mentioned in this standard shall conform to all government requirements for importation of central office telecommunications equipment into the Kingdom. For procedure on central office telecommunication equipment importation, refer to the following Material Instructions (MIs):

MI-321.015	*Materials Requiring Saudi Arab Government Import Permits, Letters of Authorization, and/or Clearance Permits*
MI-321.021	*Import Permits for Communications Equipment*

5.2 The latest recommendations of the International Telecommunication Union – Telecommunications Standardization Sector (ITU-T), as applicable, are hereby recognized as Saudi Aramco Engineering Standard SAES-T-500 "Central Office (CO) Digital Telephone Switching Systems."

The ITU-T recommendations, as specified in section 3.2, shall constitute a set of basic specifications of Central Office telecommunications equipment for deployment and interconnections with the systems currently in operation.

Any revision to ITU-T recommendations as listed in section 3.2 shall automatically be deemed to change this standard to reflect the revision.

5.3 General Requirements

All new proposed CO digital switching equipment shall meet the specifications and technical requirements described herein and shall be suitable for interconnection with the Saudi Aramco systems currently in operation without modification of the existing equipment.

Under the Engineering Standard for Central Office (CO) Digital Telephone Switching Systems, only modern system designs are required, assuring Saudi Aramco that the central office digital exchange equipment will provide cost effective service throughout their useful lifetime. System designs shall permit modular growth in both hardware and software, in order to allow rapid introduction of the latest technological changes. The switching system shall be part of a Stored Program Control (SPC) family of digital telephone exchanges with Integrated Services Digital Network (ISDN) capability, as well as capable of combining local, tandem and transit (toll) exchanges.

5.4 Design Characteristics

The Central Office (CO) digital switching system shall:

5.4.1 Be part of a family of exchange switches of different capacities.

5.4.2 Include exchanges, and remote switching units.

5.4.3 Have the capability of combining local, tandem and transit (toll) exchanges.

5.4.4 The exchanges shall be stored program control, digital electronic switching systems, capable of applications as local and remote exchanges. The exchanges shall be suitable to operate as hosts for Remote Line Switches (RLS).

5.4.5 The exchanges specified here, shall form the basis of the present and future Integrated Services Digital Network (ISDN) of Saudi Aramco. Services introduced in the future shall be compatible with all applicable ITU-T Recommendations, providing switched connections for streams of 64 kb/s.

Incorporation of ISDN services shall not cause service interruptions or changes in the existing grade of service.

Commentary Note:

The actual requirements of the above two ISDN subparagraphs 5.4.5 and 5.4.6, shall be verified during the conceptual and detailed design for each individual project, prior to the final design and implementation of the project.

5.5 Traffic Handling and Switching Facilities

The switching equipment shall handle the following types of traffic:

5.5.1 Originating Traffic

The traffic from subscribers in an exchange, destined either for the same exchange or for other exchanges, the latter case is considered outgoing traffic.

5.5.2 Terminating Traffic

The traffic in an exchange destined for its own subscribers, originating either in that exchange or from other exchanges, the latter case is considered incoming traffic.

5.5.3 Transit Traffic

The traffic in transit through an exchange, originated in another exchange and destined for a third exchange.

5.5.4 Operation and Maintenance Traffic

Is an administrative traffic generated by and destined for network maintenance and operation and not for ordinary subscriber service.

5.6 System Capacity

The Bidder and/or the Manufacturer shall provide the following information relating to the proposed switching system independent of the parameters for each exchange, which are to be separately specified:

5.6.1 Maximum system capacity to connect subscriber lines.

5.6.2 Maximum capacity of system processor to handle traffic in terms of Busy Hour Call Attempts (BHCA).

5.6.3 Maximum word capacity for each system memory to store programs and data.

5.6.4 The number of bits in each word.

5.6.5 Maximum average traffic intensity (in erlangs per subscriber line).

5.6.6 Maximum average traffic intensity (in erlangs per trunk).

5.6.7 Maximum number of outlets with complete accessibility in the selection matrix of the system, including whether this number can be increased to provide full accessibility to all of the selection matrix outlets.

5.7 Data of Individual Telephone Exchanges

The switching equipment, processors, traffic carrying units such as memories, common control equipment, power sources and other equipment (the provision of which depends on traffic) shall be calculated and dimensioned so that the exchange has the requisite initial, intermediate and ultimate capacities with the number of lines indicated at the average traffic specified per individual subscriber line and with the specified grade of service.

5.7.1 Distribution of Lines

The quantity of lines for the initial, intermediate and ultimate capacities of each exchange shall be divided into regular subscribes, PABX subscribers and other types of lines according to the relevant data.

5.7.2 Provisions of Optional Services for Subscribers

Information about optional services provided for each exchange shall include the prices of equipment, memory and programs necessary to provide subscribers with the percentage of services specified under the section of "Subscriber Services."

5.7.3 Hardware

Printed circuit boards and cable connections shall have precious-metal contact points to ensure reliable contact. Relays, if any, may be of the mini-card mounting type, and shall have protective covers. An effective number of operations shall be specified, and supporting life-test data shall be provided. Although the provided equipment will be installed and operated under a climatic control environment, must be suitable for use in the tropical conditions prevailing in Saudi Arabia.

All required terminal equipment, to be connected to the telephone network, and all trunk/line workstations, such as video display units, printers, test access units, and subscriber telephone sets, shall be in accordance with FCC Part 68, (Federal Communications Commission – U.S.A.) "Connection of Terminal Equipment to the Telephone Network, revised 1988 (& onward)".

5.7.4 Corrosion Protection

All metallic parts shall be protected against corrosion.

5.8 Mechanical Design

The mechanical structure of the system shall be designed such that the system is easy to handle. This is desired to facilitate and simplify planning, transportation, installation, operational test and maintenance.

All traffic-carrying units and functional units must be "plug-in" type units.

5.9 Modular Structure

Store Program Control (SPC) switching systems are required. Software and hardware must be modular to facilitate operation of the exchanges and to provide incremental expansion of the system.

5.10 System Maintenance

The operation of the system shall be automatically and continuously supervised by methods, which do not interrupt traffic.

5.10.1 Module Replacement

Equipment (hardware) failures shall be correctable by replacement with interchangeable units.

5.10.2 Centralized Maintenance

The system shall be equipped with inlet and outlet terminals to permit connection to a remote maintenance location, besides the local maintenance facility.

5.11 Wiring and Cables

Wiring shall be independent of the mechanical structure of the system to allow flexibility in the planning, mounting and grouping of the system elements, such as the traffic carrying and functional units.

Plug-in cables shall be used. These cables shall be precut to the proper size at the factory and supplied ready to install.

5.12 Heat Dissipation

The manufacturer shall provide a system whereby the operation of the system and the quality of service can be guaranteed in the event of failure of the ventilation of the system.

The manufacturer shall also provide details of the proposed digital exchange heat dissipation and consumption at no load and at full load for each unit and subunit of the exchange as well as the overall requirements for each exchange.

5.13 Grounding

All racks and other hardware will be equipped with grounding points, and when installed, will be grounded at the exchange room.

Refer to the SAES-T-795 "Communications Facility Grounding Systems".

5.14 Environmental Considerations

5.14.1 Electromagnetic Fields and Electrical Conditions

The digital switching equipment shall be able to withstand electromagnetic fields of the following magnitudes:

a) One (1) volt/meter for frequencies equal or below 1 GHz.

b) Ten (10) volts/meter for frequencies above 1 GHz.

The equipment shall withstand a magnetic field of 10^{-4} ampere turns per meter at frequencies under 1 KHz. In addition, the equipment supplied shall operate in buildings in which microwave equipment is installed. Refer to SAES-T-243 and SAES-T-887.

The proposed CO digital exchanges shall not be particularly sensitive to static electricity and should comply with the international recommendation for Radio-electronic disturbances.

The equipment shall comply with the following technical requirements of the regulatory standards:

a) FCC: Federal Communications Commission (U.S.A.)
Part 15, Radio Frequency Devices – Subparts B and D.

b) DOC: Department Of Communications (Canada)
CSA C108.8 (Canadian Standards Association).

Commentary Notes:

- *Electro-Magnetic Interference (EMI): EMI is the impairment of a wanted electromagnetic signal by an electromagnetic disturbance.*
- *Electro-Magnetic Compatibility (EMC): EMC is the ability of a device, equipment, or a system to function satisfactory in its electromagnetic environment without causing or suffering unacceptable electromagnetic disturbance.*
- *Measuring EMC (Radiated emissions): Radiated emissions are determined by measuring the field strength of the outgoing radiation at a specific distance from the equipment. The unit of measure is microvolts/meter (decibels above one microvolt/meter).*

5.14.2 Resistance to Light and Heat

The equipment shall not emit harmful substances when exposed to light and heat, nor shall vital parts be damaged or discolored when exposed to light.

5.14.3 Dust Protection

Equipment and maintenance requirements with respect to air purity and presence of dust particles shall be specified.

To facilitate control of dust, the manufacturer/contractor shall verify, prior to equipment's installation, that the switching/apparatus rooms are pressurized.

5.14.4 Seismic Requirements and Resistance to Vibrations

Protection must be provided for floor-mounted apparatus to prevent lateral shifting in the event of an earthquake. All power cables, bus bars and other ceiling-supporting runs must be adequately braced for earthquakes.

Manufacturers shall describe how vibrations from machines, vehicle traffic and equipment located near the exchange may affect the operation of the equipment.

5.14.5 Atmospheric Pressure

The exchange operation shall be maintained at atmospheric pressures between 0.795 to 1.05 bars under all operating conditions. When being transported, the system can be subject to pressures between 0.660 and 1.05 bars.

5.14.6 Heating, Ventilation and Air Conditioning (HVAC)

a) Climatic conditions – storage

The components of digital switching equipment shall not be damaged when stored within the following environmental ranges:

1. Temperature: 0°C (32°F) to 70°C (158°F)
2. Relative Humidity: 10 to 95%

b) Climatic conditions – operation

All digital switching equipment shall be capable of operating within the following environment limits without loss of performance.

1. Nominal Operating temperature
   - During summertime: 27°C (80.6°F)
   - During wintertime: 20°C (68°F)
2. Long-term temperature range
   - Year-round: 4°C (39.2°F) to 38°C (100.4°F)

These conditions may be exceeded during transportation. The supplied equipment must be packaged to withstand such conditions without damage.

c) For HVAC system's specifications, refer to the various applicable documents, and to the following Saudi Aramco standards:

SAES-K-003	*Air Condition System for Communications Buildings*
SAES-K-100	*Saudi Aramco Mechanical (HVAC) Code*

5.14.7 Rack and Emergency Lighting

a) Rack Lighting

Suitable rack lighting equipment, if not installed, shall be provided to illuminate the whole apparatus. The power for rack lighting shall be taken from the AC main supply.

b) Emergency Lighting

Emergency lighting from the main exchange battery shall be provided for in the exchange room and all other equipment rooms. A system for automatically switching to emergency lighting in case of mains failure shall be provided by the manufacturer/contractor.

c) For rack and emergency lighting specifications, refer to the various applicable documents, and to the following Underwriters Laboratories Inc. (UL):

UL 924	*Emergency Lighting and Power Equipment*

5.14.8 Fire Alarm and Fire Detection/Protection Systems

All new digital exchange equipment will be installed in communications buildings with fire alarm, and fire detection/protection system(s) already in place.

For fire alarm and fire detection/protection system's specifications, refer to the various applicable documents, and to the following National Fire Protection Association codes and standards (NFPA):

NFPA 12A	*Halon 1301 Fire Extinguishing Systems*
NFPA 72E	*Standard on Automatic Fire Detectors*

5.15 Memories

Processor memories, other than mass storage (tapes, disks, etc.), shall consist of nonvolatile solid-state integrated circuits. The system shall provide for the

protection of information stored in the memories during conventional power failures. Disk and/or tape units can be used for back-up storage.

With regards to the common control equipment unit(s), the system shall have a full redundancy capability.

5.16 Programs

All software dedicated to call processing and basic diagnostics shall be on-line in main memory at all times. Backup programs shall be available from overlay programs in secondary storage, when required.

5.17 Line Modules

The line units shall comply with the following specified characteristics:

5.17.1 The maximum allowed loss within any single local exchange, for local-to-local connection must be 0.5 dB from MDF to MDF (Main Distribution Frame).

5.17.2 Functions performed by the line units for the analog subscriber line (when required) shall include **BORSCHT**. {**B**attery feed (for subscriber terminals), **O**vervoltage protection, **R**inging (ringing voltage source), **S**ignaling [subscriber loop supervision (on-hook, off-hook)], **C**oding (A/D and D/A conversion to/from PCM format), **H**ybrid (two-wire to four-wire conversion), and **T**est}.

5.17.3 Digital analysis can be performed at the peripheral equipment.

5.17.4 The Pulse Code Modulation (PCM) filters and CODECs shall meet D3 and D4 format. CODECs shall use 8 kHz sampling, 8 bit/sample encoding, μ255-15 segment and A-13 segment compounding for encoding and decoding in accordance with ITU-T G.711 "PCM of voice frequencies"; and ITU-T G.732 "characteristics of primary PCM multiplex equipment operating at 2048 kb/s". ***The digital switch shall support ONLY the 32 channel A-law trunking protocol.***

5.18 Switching Network

5.18.1 Structure

The switching network shall be fully digital with a combination of time space time switching and either a duplicated network (redundancy) or equivalent arrangement to avoid significant interruption of service.

5.18.2 PCM Digital Trunks

The Network will terminate PCM lines directly, and provide for Saudi Aramco a direct digital interface via a 2048 kb/s (E1) PCM signals.

5.18.3 Inserted Connection Loss

The switch shall allow the insertion of digital loss to provide uniformity in built-up connections. The loss must be inserted via software and not by digital pads.

5.18.4 Trunk Interface

The exchange shall be equipped with digital trunk interface and when it is required with Common Channel Signaling (CCS) trunk interface.

a) Digital Trunks

Digital trunks shall be connected directly to the switching network via a digital transmission interface unit.

The digital transmission interfaces of the switching unit shall perform the following basic functions:

1. Generation of an outgoing frame code.
2. Alignment of incoming and switching frames.
3. Polar conversion and rate conversion between line and switching network.
4. Alarm processing, including incoming carrier group, alarm insertion, etc.
5. Hunting during reframe at a short time.
6. Office signal extraction and insertion.
7. Jitter elimination.
8. Outgoing signal equalization.

b) Common Channel Signaling (CCS) Trunks

The CCS trunks used for interoffice call connection shall be provided and connected to the switching network, when the common channel signaling system is used with the exchange.

c) Remote Line Switch (RLS) Interface

The RLS shall be connected directly to the switching network via a digital transmission interface unit provided at the host exchange. Interface between the remote and host switches shall meet ITU-T G.732. The RLS interface will be standardized for only 2048 kb/s (E1) PCM signals.

5.19 Descriptions of Individual Switching Systems

The following two sections present functional requirements for each of the digital switches covered by this specification. These digital switches are:

5.19.1 Local Exchange

5.19.2 Remote Line Switch (RLS)

5.20 Local Exchange

A local exchange or end office may also serve as a host exchange for RLS (Remote Line Switch). Local exchanges shall be connected to other exchanges via digital PCM links.

All administration and maintenance of the local exchange including traffic measurements, operations and maintenance, monitoring billing and system diagnostics, and call tracing, shall be provided by systems internal to the local exchange. The local exchanges shall be equipped with interface hardware necessary to be connected to its operations and maintenance center. Each local exchange shall provide control and data storage for individual call records and billing functions.

5.21 Remote Line Switch (RLS)

5.21.1 General

a) The RLS equipment shall be digital with Stored Program Control (SPC), connected to a local exchange called a host exchange, and shall be able to perform the following functions:

1. Perform intra-RLS switching of line-to-line calls within the remote switch itself.

2. Gain access to the inter-office network by switching through the host exchange.

3. Provide local service and billing at the remote location when the link to the host exchange is inoperative, with zero (0) call loss.
4. Operate as an unattended switching unit.
5. Be connected to the host exchange with PCM links.
6. Provide direct trunking to switching entities other than the host exchange.

b) The host exchange equipment shall perform the following functions for the remote line switch on a centralized basis:

1. Store data for individual calls.
2. Perform billing functions.
3. Maintain office records.
4. Offer maintenance and test capabilities.
5. Partially control calls of the RLS.

5.21.2 Administration and Maintenance

All the administration and maintenance work of the RLS, including traffic measurements and monitoring, line testing, malicious call tracing, billing and system diagnostics, modification of classes, etc., shall be accomplished by the host exchange through data links.

The service quality and the number and type of services of the RLS's subscribers shall be the same as those connected to the host exchange.

The host exchanges shall be equipped with means for remote testing and remote alarm signaling of the RLS.

5.21.3 Intra-RLS Call Function

RLS shall be able to process the total intra-RLS calls including ISDN calling and packet switching with no host support, even when all links between the host exchange and the RLS fail. In case of such failure, no calls shall be lost by the RLS.

5.21.4 Range of Applications

In general, the range of application for the RLS shall be at least 200 digital trunks or 2,000 lines. The exact number of trunks/lines will depend upon each individual project's requirements. Trade offs can be made between lines and trunks at approximately a 10:1 ratio. The RLS

shall provide service without service interruption and without changes in the number, type and quality of service offered to subscribers.

5.21.5 Billing Data

The call charging data of the RLS shall be sent to the Saudi Aramco billing system of the host exchange. If the link from the RLS to the host becomes inoperable, RLS billing data shall be retained and transferred to the host upon restoration of the link between the RLS and the host.

5.22 General Information

The following information, associated with each individual digital switching system, shall be provided during the detailed design phase, in order to meet the specifications in this document:

a) Description on how calls are analyzed, processed, and established for each type of traffic.

b) Maximum number of line and trunk terminations.

c) Maximum traffic intensity per line and per trunk (in erlangs).

d) Maximum traffic capacity of the switching system (in erlangs).

e) Maximum BHCA of system processors; and how the BHCA is calculated.

f) The false (ineffective) call attempts shall be assumed to be 25% of the total call attempts and must be added to the total call attempts when calculating the switching module subscriber stage.

g) Maximum number of simultaneous connections of trunks and lines.

h) Maximum traffic allowed for PBX trunks (in erlangs).

i) Maximum number of inlets and outlets under which full accessibility of the switch is possible.

j) Modularity and growth sequence for all traffic-carrying units and control elements.

k) Maximum memory capacity of each processor to store programs and data.

l) Main memory word length (in bits).

m) Main memory address length (in bits).

n) Estimated occupancy of processors when handling maximum BHCA.

o) Description of all software and memories that will be normally off-line, and how and when they are brought on-line during operation.

p) Description of all routines to verify availability of "off-line" data.

q) Value of crosstalk between lines.

r) Method of connecting digital subscriber lines to the switching system.

s) Switching matrix reliability regarding calls during talking state.

5.23 Integrated Services Digital Network (ISDN)

Commentary Note:

The actual requirements of the above ISDN section 5.23, shall be verified during the conceptual and detailed design for each individual project, prior to the final design and implementation of the project.

5.23.1 The ISDN capabilities will provide end-to-end digital connectivity to support a wide range of services for voice, nonvoice and future video applications. The digital exchange shall be able to provide integrated customer access for achieving circuit and packet switching simultaneously.

5.23.2 For the ISDN plan, Saudi Aramco will follow ITU-T Recommendations I-series for at least the following:

a) The concept and the principle of the ISDN.

b) The service capabilities.

c) Overall network aspects and functions.

d) User/network interface.

e) Internetwork interface.

5.23.3 Digital Customer Access

The digital exchange shall be capable of providing integrated digital customer access to provide simultaneous voice and nonvoice services from the end subscriber through the digital switching network. The integrated digital access shall provide the customer with circuit switching capabilities and packet switching capabilities simultaneously.

A variety of digital access shall be arranged to support a wide range of data rates and services. The structure of the digital access shall be in accordance with ITU-T I.412.

a) Channel Structure

The channel structure shall be the *basic* interface structure 2B+D, where the channel capacity is 64 kb/s for B and 16 kb/s for D in accordance with ITU-T I.412. The B channels may be used independently (i.e., two different simultaneous connections). This shall be valid for both the T and U interfaces.

All new and future offered switching exchanges, shall be capable of and comply with the *primary* interface structure 30B+D, where the D channel in this case is 64 kb/s. (The primary data rate is 2.048 Mb/s).

b) Transmission

The bit rate as well as other physical characteristics of the T interface shall be in accordance with ITU-T I.430. The transmission rate on the Digital Subscriber Line (DSL) over the U interface shall be 192 kb/s.

c) D channel access protocol

The D channel access protocol shall be structured in three layers as follow:

1. Physical layer (layer 1)

   This layer shall provide the electrical, mechanical, functional control of data circuits, characteristics and procedures to activate and deactivate the physical link and shall be in accordance with ITU-T I.430 for the basic rate and ITU-T I.431 for the primary rate.

2. Link layer (layer 2)

   This layer shall establish, maintain, and release data links, error and flow control. This layer provides information transportation between the digital subscriber set and the exchange. The link layer procedures shall be in accordance with ITU-T I.440 for the basic rate and ITU-T I.441 for the primary rate. *(ITU-T I.440 & I.441 are published under alias number ITU-T Q.920 & Q.921 respectively).* Besides ITU-T I.440 and I.441, the following recommendations and standards are referenced: ITU-T X.200; X.210 Open System Interconnection (OSI) and X.25 Link Access Protocol (LAP.B/D). Also International Standard

Organization ISO 3309 and ISO 4335 (High Level Data Link Control (HDLC) standards for frame structure and elements and procedures).

3. Network layer (3)

This layer provides the means to establish, maintain, and terminate network connections across an ISDN between communicating application entities. As a minimum, this layer shall provide the necessary signaling functions to support the ISDN services indicated in the next paragraph. The network layer shall be based on ITU-T I.450 and I.451, *which are published under alias numbers ITU-T Q.930 and Q.931 respectively.*

5.23.4 ISDN Services

The digital exchange shall be capable of providing, as a minimum, the following types of services for the ISDN:

a) Supplementary telephone services using digital telephone terminals including display functions and alpha-number key sets.

b) Possible to interwork with the existing packet and circuit switched data networks by means of an adapter for connecting x and v type terminals.

c) Packet switched services according to ITU-T X.25 protocol.

d) Leased line at 64 kb/s by using semi-permanent connection through the digital switching network.

e) Alarm services by using the digital access to provide information transfer to an alarm/network operation center.

f) Telemetry services by using the digital access to fetch the readings in the subscriber end.

g) ISDN fast facsimile services, telex/teletex, video (slow scan) for teleconferencing, etc., via the H-channel's capability for higher user data rates. [H0: 384 kb/s; H1: 1536 kb/s (H11) and 1920 kb/s (H12)].

h) Broadband ISDN (B-ISDN) services at n x 64 kb/s in future.

i) Full support of the latest Digital Subscriber Line (DSL) technology.

5.23.5 Network Capabilities

For telephone service, the numbering plan and charging method provided by ISDN shall remain unchanged. It must be possible to enhance the network capabilities when new services are introduced in the ISDN. Network signaling shall be in accordance with ITU-T Recommendation SS No. 7 (Signaling System No. 7) with possibilities to introduce the new ISDN user part (ISUP).

5.24 Traffic Requirements

5.24.1 General

Individual exchanges shall be dimensioned to meet both the general traffic requirements given in this section and the specific requirements for number of lines and trunks, number of Busy Hour Call Attempts (BHCA), and other characteristics peculiar to individual exchanges.

5.24.2 Grade of Service

a) Dial Tone Delay

Is the time elapsed from off-hook of a telephone set to the initiation of dial tone, and at the worst case shall not exceed 3 s 98.5% of the time.

The number of call initiations encountering dial tone delays of more than 3 seconds shall not exceed 1.5%. This value will be calculated as an average, taking measurements during the busy hours of business days during the busy season.

b) The average dial tone delay shall not exceed 600 milliseconds.

5.24.3 Traffic Carrying Units

Traffic carrying units (such as trunks) shall provide a grade of service not less than 0.005.

5.24.4 Functional Units – Service Circuits

Functional units shall provide a grade of service not less than 0.001.

Service circuits shall provide a grade of service not less than that specified in paragraph 5.24.2 (Dial Tone Delay).

5.24.5 Post-dial Delay

The post-dialing delay is one of the principal measures of performance of a signaling system, and is defined as the amount of time it takes after the calling subscriber completes dialing until ring-back tone is received.

The average post-dialing delay (for digital systems) shall not exceed 1 second, including the circuit operation and translation time. However, should be noticed that the ITU-T Q.709 "Hypothetical Signaling Reference Connection" specifies no more than 2.2 seconds of post-dial delay for 95% of calls.

5.24.6 Blocking Probability

The following maximum probabilities shall be met under traffic conditions specified throughout in sections 5.5 – 5.22, and shall not include losses that might occur at line modules.

The line unit blocking factor for the digital exchange, shall be 0.5% of total calls or less.

a) The intra-office matching loss shall not exceed P = 0.005

b) The outgoing matching loss shall not exceed P = 0.005

c) The incoming matching loss shall not exceed P = 0.005

d) The register's loss shall not exceed P = 0.001

e) The switching network matching loss shall not exceed P = 0.005

5.24.7 Availability

The digital exchange shall have full availability to all outgoing trunks in a group. The availability of incoming trunks is a function of the originating exchange design (outgoing trunks of originating exchange).

5.24.8 Overload Conditions

During operation of the exchange it will be assumed that overload conditions exist when either the offered traffic rises to 10% above normal load, or the number of call attempts rise to 20% above normal load. Overloads may be extended for a period of an hour or longer, and the exchange must be able to provide service during such periods. Calculations or simulation results must show how the characteristics in paragraphs 5.24.2, 5.24.3, and 5.24.4 are affected under up to 10% excess traffic in 5% increments; plus up to 20% excess call attempts in

5% increments. During overload conditions none of the above matching loss characteristics shall increase by more than a factor of two (2).

The average daily busy hour traffic shall be assumed to be equal to the average of the traffic for ten average busy hours on ten different days.

5.24.9 Load Control under Emergency Conditions (Priority Service)

Under emergency conditions, service to priority subscribers shall be maintained by load control. The load control must be initiated and carried out automatically by the system via keyboard and a Video Display Terminal (VDT) from the exchange maintenance center, or from remote location. There will be at least two categories of priority subscribers. All switches must be equipped with emergency features remotely controlled by a terminal over a line or a derived circuit. Safeguards must be provided to prevent incorrect or accidental actuation of these emergency features, and the remote terminal must be acknowledged by an answer signal indicating that the emergency condition has been set up.

5.25 Types of Traffic

The exchange shall handle traffic to and from, as follows:

5.25.1 Subscribers connected within their own exchange (including all subscribers of host and remote exchanges).

5.25.2 Other local exchanges (originating, terminating, and transit).

5.25.3 Tandem, toll, and international exchanges.

5.25.4 PABX's

5.25.5 Announcement machines (connected to exchange).

5.25.6 Operator services (including trunk offering by operators).

5.25.7 Test equipment in the exchange.

5.25.8 Coin Box services (for special cases like in new developing areas, during construction, etc., where the services might be required).

5.26 Traffic Loads

All digital exchanges shall be designed to handle average subscriber traffic loads (bothways) of 0.8 erlang per trunk during the busy hour.

Commentary Note:

It is recommended that all digital exchanges should be designed to handle an average of 0.1 erlang per line for low traffic exchanges, and 0.18 erlang per line for high traffic exchanges.

5.27 Average Dialing Time

Commentary Note:

The following reference information is provided for the design of the switching system:

5.27.1 Pre-dial interval: 2.0 seconds (time after receiving a dial tone before the subscriber starts dialing).

5.27.2 For DTMF (Dual Tone Multi Frequency): 0.6 seconds for each digit.

5.27.3 For rotary dialing: 1.5 seconds for each digit.

5.27.4 MF (Multi Frequency) sender signaling: 10 digits per second.

5.28 Average Holding Time

Commentary Note:

The following reference information is provided for the design of the switching system:

5.28.1 Dialed Calls:

a) Local calls …….. 150 seconds

b) Calls to special services …….. 80 seconds

c) DDD calls (national) …….. 100 seconds

d) IDDD calls (international) …. 120 seconds

5.28.2 Manual Calls:

a) National via operator ……. 180 seconds

b) International via operator ….. 380 seconds

5.29 Statistics and Measurement of Traffic

The switching system shall be capable of providing traffic measurement reports. These reports shall be automatically printed on a system printer and on a remote teletypewriter or video display unit, at time intervals determined on command given by the operating personnel locally at the exchange or remotely at a remote location.

5.29.1 Reports on Command

a) The switching system shall provide the following reports on command:

1. Traffic in erlangs.
2. Number of call attempts.
3. Percentage of successful calls.
4. Average holding time.
5. Number of equipped device (line module, network module, Dual Tone Multi Frequency (DTMF) registers, etc.) and number of blocked devices out of service.
6. Congestion.
7. Percentage of overflow.
8. Others.

b) The reports shall include the following types of traffic.

1. Intra-calls.
2. Local calls, coin box, and PABX.
3. DDD (Direct Distance Dialing (national)) calls.
4. IDDD (International Direct Distance Dialing) calls.
5. Operator-assisted calls.
6. Special services and subscriber's services.
7. Special services and subscribers, covered in the ISDN.
8. Others.

5.29.2 Scheduled Reports

The digital switching system shall have the capability and flexibility of providing, per request and under software control, various scheduled reports with specified parameters/values.

a) When previously specified values for a given measurement period are met, an automatic printout shall be made at the maintenance center. Saudi Aramco shall be able to modify the following report schedules by command:

1. Percentage of delayed calls per exchange.
2. Percentage of blocked calls per module.

3. Percentage of blocked calls per trunk group.

The printed out reports shall include at least the information described on the following sub-paragraphs (b, c, d & e), plus a system-wide summary:

b) Switching equipment (line module, network module, common control, etc.):

1. Peg count of seizures.
2. Usage in erlangs per line unit.
3. Average holding time.

Each kind of traffic-sensitive equipment shall be reported individually.

c) Subscriber Lines

1. Attempts: Number of originating and terminating calls offered per line unit.
2. Usage in erlangs per line unit.

d) Trunk Group

1. Peg count of seizures per outgoing/incoming group.
2. Peg count of the number of overflows per outgoing trunk group.
3. Usage per trunk group; the erlangs per incoming and outgoing trunk group.
4. Average holding time in seconds per trunk group.

e) Dial Tone Delay

1. Average dial tone delay per line module in increments of 0.3 second.
2. Number of test calls per line module.
3. Number of calls delayed more than specified threshold time per line module.

5.29.3 Monitoring of Trunking Network

The trunking monitoring system shall allow for automatic traffic observations of calls and fault tracing on certain trunks or trunk groups that can be selected for study.

5.29.4 Service Quality

Service observation shall be available to determine the quality of service provided to subscribers in the following traffic cases:

a) All originating connections.

b) All incoming connections.

c) Specific incoming trunk groups.

d) Number of calls.

e) The number of times the calling subscriber dials non-existent subscriber numbers.

f) Percentage of completed calls, answered calls.

g) Percentage of non-completed calls:

1. Number of calls when the called subscriber line is free, but the called subscriber does not answer.

2. Number of calls that are not completed because the called subscriber is busy.

3. Total number of completed calls and non-completed calls.

4. Number of calls that do not mature for other reasons.

5.30 Call Handling, Routing and Signaling

5.30.1 Numbering Capability

The exchange shall have the capacity to provide for five, six and seven digit subscriber numbers, plus one, two, or three digit area codes, and one zero (0) or two zero (00) access codes. International numbers shall have up to sixteen (16) digits.

A minimum of 256 classes of service shall be provided for lines, and also a minimum of 256 classes of service shall be supplied for trunks.

The CO exchange shall be part of the integrated national numbering scheme of the Saudi Telephone Company (STC) for Saudi Aramco.

The exchange shall be capable of providing the following services (depending upon the requirements of each individual site), consistent with the numbering plan and relevant originating and terminating classes of services:

a) Local Services.

b) Special Services.

c) National and International long-distance services.

d) Optional services to subscribers.

5.30.2 Digit Processing, Storage and Analysis

The exchange shall have the capacity to store up to 16 digits and analyze the relevant digits according to the specified numbering plan.

The offered exchanges shall allow sufficient analysis to satisfy the requirement of the present and future numbering plan. The analysis shall be able to deal with a number of digits that may range up to eight (8).

It shall be possible to modify the analysis tables during exchange operation without interrupting traffic handling.

In addition to the ability to recognize the digit key signals, exchanges shall have the capacity (via the DTMF calling devices) to store and respond to the signals (*) and (#), and to signals A, B, C, and D, corresponding to the fourth column of the DTMF (Dual Tone Multi Frequency) keyboard.

5.30.3 Number Allocation

The system shall allow the allocation of a subscriber line to any equipment position in the exchange, without changing the directory number assigned to it.

PABX numbering shall not require a special series of numbers. The facility to analyze all digits of PABX directory numbers, whatever the size of PABX route, shall be available. PABX number need not be consecutive.

5.30.4 Call Hold and Call Release

Under normal conditions, calls shall be held under control of the calling party. Exceptions to this rule will be as follow:

a) Malicious Calls (Harassment/Nuisance Calls)

Call release will be under control of the called party.

b) Manual Hold

Manual hold by the operator is required, under the following special cases:

1. When the called party does not answer, ringing is applied until the calling party or a programmable time out (90 seconds) releases the call. After the release, the calling party and the called party shall be free.

2. When the called party releases first, the calling line will revert to a busy tone after a time of 4 to 120 seconds (adjustable).

3. When the calling party releases first, the called line is put into line lockout until the called party hangs up.

c) Release Supervision

Supervision of call release shall be as follows:

1. For intra-office and outgoing calls release of the connection shall be controlled by the calling subscriber after completion of the call.

2. For the combined line recording calls, release of the connection shall be controlled by, both the operator and the calling subscriber.

3. For local calls, the exchange equipment shall automatically release (force release) either party, if one of them fails to hang up within a time period of up to 45 seconds after the other party hangs up.

4. DDD/IDDD Calls

When the exchange switch serves as the charging point for DDD and IDDD calls, control of the circuit release shall be as follows:

- If the calling line goes on-hook first, the circuit shall be release within 240 ms.

- If the called line goes on hook first and the calling line remains off hook for longer than 10 seconds after the succeeding office has returned a clear back signal (an on

hook), the exchange shall send an on hook toward the succeeding office with a minimum duration of 240 ms to force release of the succeeding office and the reorder tone shall be returned for 30 seconds to the originating office. However, if the succeeding office returns an off hook signal before 10 seconds have elapsed after the exchange receives the clear back signal from the succeeding office, the clear back signal shall be ignored.

d) Special Cases of Call Handling

The call handling of special cases shall be as follows:

1) When the called line is busy or in line lockout, a busy tone shall be returned to the calling line.

2) When the called line is out of order, denied, spare, or temporarily out of service, connection to a recorded announcement shall be made.

3) When a subscriber dials a code or number not permitted according to his class of service, the call shall be routed to a recorded announcement.

4) Malicious Calls (Harassment/Nuisance Calls)

When a subscriber's line is set up for malicious call trace, the following procedures shall apply:

- Printout report of a called line

  If subscribers on a particular line or PABX group complain of receiving malicious calls, the group may be marked for observation as a "malicious call receiver". In that case, each time that a call is completed to a "malicious call receiver", a printout report shall be made indicating the identity of the calling line or trunk, the called number, the date, and the time of day.

- Printout report of calling line or trunk

  When a particular line or trunk group is suspected of originating malicious calls, it can be marked for observation as a "malicious call originator". Each time that a call is originated by a "malicious call originator", a printout report shall be made indicating the identity of

the calling line or trunk, the called number, the date, and the time of day.

- Exchange alarm in response to switch-hook flashing

  When a subscriber line has been marked as a "malicious call receiver", this party can give a "switch-hook flash" when receiving a malicious call. The "switch-hook flash" must cause an audible alarm at the local exchange where the party is connected and printout the calling subscriber number.

5) PABX Direct Inward Dialing (DID)

Provision for direct dialing shall be provided for all PABXs (Private Automatic Branch Exchange). The numbers allocated for DID PABXs shall be integrated within the national numbering plan. For billing purposes, the local exchange shall be equipped to send answering signals to the PABX when the called party answers.

6) PABX Outward Dialing

Outward dialing shall be possible from a PABX to the local exchange.

e) Verification Calls

Operators shall be able to place verification calls by dialing the subscriber line number receiving an audible tone from the switch.

f) Trunk Offering

Local exchanges shall be equipped with trunk offering facilities to enable operators or test personnel at a remote center in the network to override an engaged subscriber without breaking the establish connection. The exchange shall supply a warning tone. Also the local exchanges shall be equipped to allow marking of subscriber lines by category in order to inhibit operator intrusion.

5.30.5 Signaling

The signaling of the exchange shall be compatible with the Saudi Aramco's existing signaling systems. Furthermore, the exchange shall be able to operate with Common Channel Signaling (CCS), and

support ITU-T recommended Channel Associated Signaling (CAS) in time slot 16 of the 2.048 Mb/s (E1) facilities terminating on the switch.

(For "data link layer specification" see ISDN on section 5.23 of this standard).

a) National Signaling System

The exchange shall be capable of supporting, as a minimum, the basic signaling codes and schemes identified bellow:

1. DC Loop Line Signaling (2-Wire)

   The DC loop line signaling is used for one-way operation over 2 wire circuits in combination with Multi Frequency Code (MFC) register signaling.

2. Discontinuous Line Signaling

   The discontinuous line signaling is used for one-way or both way operations over 4 wire circuits in combination with MFC register signaling. The signals can be sent out-band or in a digital form Pulse Code Modulation (PCM) circuits.

3. PCM Line Signaling for 32 Channels (E1)

   The 32 channel PCM signaling is for one-way operation over 32 channel PCM circuits.

4. Register Signaling

   A Multi Frequency Code (MFC) with six frequencies in the forward direction and four in the backward direction is used for register signaling. Any signal, in either direction, is distinguished by the simultaneous transmission of two frequencies. The numeric signals are sent in the forward direction and the control signal in the backward direction. The signals are transmitted from a sender and are received in a register (or a receiver); hence, there are registers and senders at each end of the signaling path.

   - ITU-T Signaling System No. 7

     The national version of ITU-T SS No. 7 shall be according to ITU-T Q.701-707 [Message Transfer Part

(MTP)], and Q.721-725 [Telephone User Part (TUP)]. The interface for the 2048 kb/s primary shall conform to ITU-T G.704 (synchronous frame structures), where there are 32 time slots per frame, numbered 0 to 31, and the number of bits per frame is 256 (8X32). The 8-bit frame alignment occupies position 1 to 8 in time slot 0 of every other frame in the CEPT30+2 format. See section 5.23 for additional information about ISDN.

- Signaling for International Traffic

  The CO digital exchanges shall comply with ITU-T Signaling Systems No. 1, No. 5, No. 6, and R2. Also, the CO digital exchanges shall comply with ITU-T Signaling System No. 7 regarding ISDN capabilities, unless otherwise will be stated by Saudi Aramco in writing.

  Commentary Note:

  The following reference information, associated with the R2-Multi-Frequency Code (R2-MFC) register signaling requirements, is provided for the design of the switching system and shall be verified during the detailed design of each project.

  (For "data link layer specification" see ISDN on section 5.23 of this standard).

  R2 - MFC

  Generally, as is defined in the ITU-T Recommendations Q.440 and Q.441. Specifically, frequencies shall be as specified in Table 4/Q.441. ***At the present time, Saudi Aramco is using the ETSI-PRI signaling for the Lucent's No. 5ESS Central Office (CO) & PABX switches, and the EURO-ISDN signaling for the Nortel's DMS & Meridian switches. However, the Saudi Telephone Company (STC) and Saudi Aramco's implementation of multi-frequency compelled register signaling varies somewhat from the ITU-T Recommendations.*** *The exact meaning of the forward and backward signals within the Saudi Aramco's network, and between the Saudi Aramco's and STC's networks, are defined below:*

Forward Group I *(Note 1)*		
Digit	**Send**	**Receive**
1	ITU-T *(Note 2)*	ITU-T
2	ITU-T	ITU-T
3	ITU-T	ITU-T
4	ITU-T	ITU-T
5	ITU-T	ITU-T
6	ITU-T	ITU-T
7	ITU-T	ITU-T
8	ITU-T	ITU-T
9	ITU-T	ITU-T
10	ITU-T	ITU-T
11	*(Note 3)*	*(Note 3)*
12	NS *(Note 4)*	INV *(Note 5)*
13	NS	INV
14	NS	INV
15	ITU-T	ITU-T

Forward Group II		
Degit	**Send**	**Receive**
1	ITU-T	ITU-T
2	ITU-T	ITU-T
3	ITU-T	ITU-T
4	NS	ITU-T
5	*(Note 6)*	*(Note 6)*
6	NS	Treat as II-1
7	NS	Treat as II-6
8	NS	Treat as II-2
9	NS	Treat as II-1
10	NS	Treat as II-1
11	NS	Treat as II-1
12	NS	Treat as II-1
13	NS	Treat as II-1
14	NS	Treat as II-1
15	NS	INV

Backward Group A		
Digit	**Send**	**Receive**
1	ITU-T	ITU-T
2	ITU-T	ITU-T
3	ITU-T	ITU-T
4	ITU-T	ITU-T
5	*(Note 7)*	*(Note 7)*
6	ITU-T	ITU-T
7	ITU-T	ITU-T
8	ITU-T	ITU-T
9	NS	INV
10	NS	INV
11	NS	INV
12	NS	INV
13	NS	INV
14	NS	INV
15	NS	INV

Backward Group B		
Digit	**Send**	**Receive**
1	ITU-T	ITU-T
2	NS	ITU-T
3	ITU-T	ITU-T
4	ITU-T	ITU-T
5	ITU-T	ITU-T
6	ITU-T	ITU-T
7	ITU-T	ITU-T
8	ITU-T	ITU-T
9	NS	INV
10	NS	INV
11	NS	INV
12	NS	INV
13	NS	INV
14	NS	INV
15	NS	INV

Notes:

1. Digits 1-10 are used as address digits
2. ITU-T = same as ITU-T Recommendations Q.440 through Q.480.
3. Same as first forward digit if line status is marked by the digital Central Office (CO), associated with the PABX, as Charged Number Intercept. The call is routed to Charged Number Intercept Recorder. ("I" trunk group to be dedicated at time of data base engineering). "I – 11" is never sent to STC.
4. NS = Never sent within the Saudi Aramco network or to STC.
5. INV = Treat as invalid if received.
6. II-5 is sent and received within the Saudi Aramco network.
7. A-5 following any other Group A signal indicates request for calling party's category. A-5 immediately following an A-5 indicates send first or next digit of calling party address [Automatic Number Identification (ANI)]. The receiving exchange may request return to sending called party address by returning A-1, A-2, A-7 or A-8 at any time during transmission of category or ANI.

The CO digital switching system shall be capable of meeting the requirements of ITU-T Recommendation G.121 for digital switching interfacing to the Saudi Aramco telephone network, and capable of sending and receiving Multi-Frequency Code (MFC), Dual Tone Multi-Frequency (DTMF), and Dial Pulse (DP) signaling.

5.31 Line and System Interfaces

This section contains the specifications for line and systems interfaces associated with the CO digital switching system. All trunk interfaces shall be digital.

5.31.1 Operating Limits

The following operating limits apply to the switching equipment and all associated miscellaneous circuits.

a) Operating Voltage

All digital exchange equipment requiring direct current, shall be designed to operate at a nominal voltage of -48 Vdc. The operating voltage may vary from -44 to -52 Vdc with positive polarity to ground, and the CO digital equipment shall be designed to operate normally within this voltage range.

b) Subscriber Lines Supervision Limits

1. Loop resistance

The loop resistance shall be 2000 ohms (maximum), including the telephone set (either rotary or Dual Tone Multi Frequency (DTMF) type). The switch shall support subscriber line impedances from 2000 to 3000 ohms by using external range extenders.

The digital switches shall provide a ground-referenced battery and loop current feed. Since the loop current will vary for each loop resistance, the maximum loop resistance of 2000 ohms shall maintain a minimum loop current of 18 to 24 mA, while the maximum current limit of line circuits is 48 mA.

2. Telephone set(s)

A maximum of four (4) telephone sets in parallel operation shall be allowed on the line.

3. Insulation resistance

   The insulation resistance shall be 20000 ohms (minimum) measured between the a or b wire to earth and between the a to b wire.

4. A short circuit anywhere in a subscriber line shall not cause any damage to the exchange equipment.

5. The subscriber line circuit shall be protected against high voltage greater than 110 volts ac. References shall be made to SAES-T-435 "Station Protection" and SAES-T-243 "Protection Equipment in Communication Buildings".

c) Digit Receivers

The following sub-sections state the requirements for the subscriber digit (dial pulse) receivers:

1. Dial Pulse Receivers

   The equipment shall accept dial pulses within the following limits:

   - Dial speed (decadic): 8-16 pulses per second.
   - Make break ratio: 50-50 and 33-67.
   - Inter-digit interval: 200 milliseconds minimum. (between dial pulse digits)

2. DTMF Receivers

   The DTMF receivers shall accept two voice frequencies selected from separate groups of frequencies. The exchange must have the potential ability to cater the signals A, B, C, and D, corresponding to the fourth row of the key-board, when these signals are provided. The corresponding digital symbol, or letter, for the combination of a low-group and a high-group frequency is as follows:

Low Group	High Group			
Frequency (Hz)	(H 1)	(H 2)	(H 3)	(H4)
	1209	1336	1477	1633
(L 1) 697	1	2	3	A
(L 2) 770	4	5	6	B
(L 3) 852	7	8	9	C
(L 4) 941	*	0	#	D

The receiver's performance shall comply with the following limits:

Receiving level (high, low group): -3 to 24 dBm.

Maximum level difference between two frequencies: 5 dB.

Frequency deviation: within plus/minus 2 percent (± 2%).

Signal length: not less than 40 milliseconds.

3. Incoming Calls

Receivers shall accept and register multifrequency pulsing from incoming trunks.

4. Digit Registration

- For LOC calls, receive a maximum of 7 digits.
- For LDD calls. Receive a maximum of 11 digits including prefix "0" for nationwide dialing.
- For IDD calls, receive a maximum of 16 digits including prefix "0" (zero).

d) Interconnection Control

The CO digital switch shall comply with the following sub-sections that state the requirements for the routing, interception, and trunk continuity test:

1. Routing

The outgoing traffic routing shall be flexible, so that it can be changed with minimum internal modification. It shall be possible to arrange each trunk subgroup for one-way outgoing and/or two-way (both ways) operation. The outgoing routes (one-way outgoing and two-way trunk

subgroup) shall have available at least 512 routes in addition to the alternate routing capabilities.

2. Interception

The interception service shall be served by either a voice mail or a voice announcement machine.

3. Trunk Continuity Test

During the process of establishing a call through a switch and interconnecting with trunk, a continuity check of the trunk shall be made by the switch, prior to outpulsing the dialed digit.

e) Line Lockout

Line lockout shall be provided for all equipped lines to release the occupied links for the following cases:

1. When the subscriber fails to start dialing within an adjustable time interval of 10 – 20 seconds after receiving dial tone.

2. When the subscriber fails to end dialing within an adjustable time interval of 20 – 30 seconds after start dialing.

3. When a line is in an incorrect off-hook state.

Note: In each of the above cases, a busy tone and a "receiver off-hook" (howler) signal shall be applied to the subscriber line for one minute without the use of permanent trunks. It also shall be possible to route that line to an announcement machine, if required. Time periods indicated above, shall be adjustable by software.

f) Subscriber Supervision

Subscriber supervision shall be effective over the operating range of -44 to -52 Vdc up to the line limit specified previously under section 5.31.1. To conserve energy, a constant current source shall be used as the feeding bridge.

g) Operating Features for Trunking Application

The CO digital switches shall perform the following functions depending on the signaling type used:

1. Signal Recognition

   The exchange shall repeat supervisory signals from the called station toward the calling station whenever it is necessary.

2. Trunk Assignments

   a. It shall be possible for each trunk route to operate as one-way incoming trunks, one-way outgoing trunks, and two-ways R2 trunks.

   b. For trunk switch application, at least 512 outgoing (one-way and two-ways outgoing trunks) routes shall be available in the CO digital exchange in addition to the other types of trunks.

   c. At least 500 trunks per route (incoming, outgoing, and/or two-ways trunks) shall be assignable.

   d. The following trunk subgroup assignments shall be possible:

      - Incoming (ICT), outgoing (OGT), and two-ways (2WT) trunk subgroups to one exchange unit.
      - Either ICT or 2WT from or to one exchange unit.
      - ICT, OGT, and 2WT from or to several exchange units.
      - Either ICT or OGT or 2WT from or to several exchange units.

   e. It shall be possible to assign all trunks in one trunk subgroup to any switching network group or, separately, to several switching network groups.

3. Route Advance

   A method of advance route with a minimum of four trials in additional to the direct route for multi-alternate routing shall be provided. The call then shall be routed to overflow ("all trunks busy" tone) when all paths are busy.

4. Trunk Classes

The exchange shall be equipped with class of service indications for trunk group identification. The exchange shall also be equipped to increase the number of classes of services.

5. Service Restriction

The exchange shall be equipped to prevent connections that are restricted. A selective basis for prevention and a means to route such calls to busy-tone-trunks shall be provided.

6. Intercepting Facilities

a. Facilities shall be provided to intercept calls that cannot be completed due to the following conditions:

- Partially dialed or incorrectly dialed.
- Vacant codes dialed.
- Changed codes dialed.
- Switching machines congestion or network congestion.

b. Voice announcement machines for intercepting messages for the calls specified above shall be provided with the following capabilities.

- The machines shall have an announcement interval that may be varied from 3 to 24 seconds.
- Where required, an amplifier or several amplifiers of sufficient power to handle 200 intercepted calls shall be provided.

c. Intercept trunks for each announcement and reorder tone shall be provided. All of the intercept trunks shall be optionally assignable for any announcement or reorder tones. The exchange shall be equipped to send a reorder tone to the calling subscriber in case the calling subscriber still remains off-hook after the machine stops sending the recorded announcement.

5.32 Call Charging

In the present Saudi Aramco network, a combination of Local Automatic Message Accounting (LAMA) and Periodic Pulse Metering (PPM) systems are used for charging of calls. LAMA is used in the Stored Program Control (SPC) digital switching exchanges. All digital local exchanges shall be equipped with LAMA facilities for charging of local calls, toll calls, and international calls as well as voice and non-voice calls. The exchanges shall have the capability to generate multimetering pulses locally, whenever it might be necessary, for local calls made within the unit fee area.

Commentary Note:

A Centralised Automatic Message Accounting (CAMA) system is more economical and preferable, than the presently used LAMA system, for all local areas where a CAMA facility can serve two or more CO exchanges within the Saudi Aramco telecommunications network.

5.32.1 Tariffs and Free-of-charge Calls

The tariffs, which are applied for each individual local charging area to all other local charging areas in different zones, are decided by the dialed digits. Tariffs can be changed via a "change procedure" during normal traffic. These changes should be verified off-line prior to implementation on the digital switch. The exchanges shall allow for charge-free calling to specified lines.

5.32.2 Operational Test Features for Call Counting and Registration Systems

The exchanges shall be equipped with software and hardware terminals necessary to make operational tests on the registration systems and to charge tariffs by modifying data during normal exchange activity, without disturbing ongoing traffic. The call counting and registration system shall allow for verification and testing of tariff changes before they are put into effect.

5.32.3 Automatic Number Identification (ANI) of Calling Subscriber

The exchanges shall be equipped with Automatic Number Identification (ANI). The directory number corresponding to A-subscriber, his interurban prefix and category shall be available at any moment during the establishment of a call, so that it may be retransmitted if requested. The manufacturers shall state the number of different A-subscriber categories that may be stored and retransmitted as responses to a request made by another exchange using Multi Frequency Code (MFC) register signaling. They shall also state if the categories depend on the system's signaling capacity and if it will be possible to expand the number of category groups in the future.

5.32.4 Storage of Data

The call-charging data stored in the buffer memory area of the local exchange shall be periodically transferred to a magnetic tape, or similar arrangement, in the same exchange. The magnetic tape unit used to store billing data, shall be duplicated. The exchange shall have the capability to transfer call charging data to an operation and maintenance center via a data link. It is essential that the buffer memory area retain (protect) its information until it can be transferred to the storage tape.

5.32.5 Local Automatic Message Accounting (LAMA) System

The following features shall be included in the Local Automatic Message Accounting (LAMA) system of the exchanges:

a) For telephone calls, the LAMA system shall provide detailed information for each call.

b) For data calls, the LAMA system shall have the capability of being used for the purpose of call-charging.

c) Supervision of LAMA system shall be performed through a data terminal. Automatic fault detection, automatic diagnosis and fault localization shall be built in the LAMA system. Maintenance instructions to replace a faulty module shall be recorded at the terminal.

d) The following data shall be recorded, when required, in single entry format:

1. Local calls:

- Type of call.
- Calling number.
- Date (Julian).
- Time of called party answer (hour, minute, 10^{th} of minute).
- Duration of call (hour, minute, 10^{th} of minute).

2. Long Distance Dialing calls (LDD) and International Direct Distance Dialing calls (IDDD) for combined local and transit:

- Type of call.
- Calling number.
- Called number (dialed digit).
- Date (Julian).
- Time of called party answer (hour, minute, 10th of minute).
- Duration of call (hour, minute, 10th of minute).
- Date change over (midnight) identification.

5.32.6 Charging Observation

The exchange shall enable billing processes to be checked, both on a routine basis and on a demand basis, to respond to subscriber complaints. The following information shall be provided to enable Saudi Aramco to inform subscribers about the correctness of their bills:

a) Date/time of origin of each call, outgoing and incoming.

b) Called number and time at which each call was placed.

c) Time at which subscriber answered.

d) Duration of call.

5.32.7 Charging Statistics

It is required that the charging system shall be equipped to provide charging statistics, for planning purposes and tariff adjustments. Recorded data shall include the number of calls and the number of meter-pulses registered for those calls during a given period of time.

Activation and deactivation of the gathering of charging statistics shall be initiated by command. When a recording is ended, recorded data shall be output automatically. It shall be possible to output data on a printer/display or on a magnetic tape device, or to send data directly over a data link to a computer center.

The data to be printed out shall consist of the following:

a) Tariff of each call type.

b) Date and time when the recorder was started.

c) Start and stop time for each time period.

d) Number of the calls and/or number of the meter pulses for each time period for each call type.

5.33 Subscriber Services

5.33.1 Telephone Service

Telephone service provided by the digital exchanges shall include Dual Tone Multi Frequency (DTMF) dialing and rotary dialing, with access to local calls, toll calls, international calls, all operator services and all other special subscriber features.

5.33.2 Classes of Service Required

The digital exchanges shall include but not be limited to the following classes of service: **(The actual Classes of Service Required and the percentage of exchange lines, for each class of service, shall be determined and verified during the detailed design of each project)**.

a) Line under service observation for observing quality of service on subscriber calls. This may be local or centralized, as required.

b) Line under malicious call hold: 0.5% of exchange lines.

c) Spare line.

d) Changed number of service interception with rerouting to operator.

e) Changed number with rerouting to announcement circuit.

f) Line temporarily out-of-service.

g) Abbreviating dialing, if required, with entry of code under subscriber's and/or exchange control. It must be possible to store at least 30 numbers per subscriber: 0.5% of exchange lines.

h) Call waiting service, which permits a subscriber engaged in conversation to receive an audible signal, indicating that a third party wishes to talk to him: 0.5% of exchange lines.

i) Hot line, with path set through switching equipment giving callers direct access to predetermined party without dialing: 0.5% of exchange lines.

j) Three-way Calling Service: This service permits a subscriber to add a third party to an existing conversation. This is done on any call placed by or received by the subscriber: 0.5% of exchange lines.

The manufacturer shall assume that a subscriber having the three-way calling feature shall use the feature 10% of the time. The following shall be considered acceptable average holding times for both local and toll exchanges combined:

1. 120 seconds: Average call holding time.
2. 300 seconds: Average conference call holding time.

k) Call Forwarding: This service permits a subscriber to have all incoming calls transferred to some other local or toll destination. The system is arranged to allow the customer to specify this destination when activating the service, and to be able to activate or deactivate the service, from his telephone: 0.5% of exchange lines.

l) Do Not Disturb: When a line has the service activated, it is not rung on incoming calls. The calling party receives an announcement. The line can originate calls while the service is activated: 0.5% of exchange lines.

m) Wake Up: The system is arranged so that a subscriber with this feature can be recalled at a requested time. The subscriber can assign any hour and minute within the next 24 hours: 0.5% of exchange lines.

The wake up call is made at the requested time, and the line is rung for 35 seconds. If the first attempt reaches a busy line or results in no answer, a second trial is made 10 minutes later. If there is no answer to the second trial, a printout is made.

n) Manual line (off-hook) service, which is providing an automatic connection to an operator for handicapped subscribers: 0.5% of subscriber lines.

o) Multiline Hunting: This feature is applicable to individual lines, in WATS, PABX, and CENTREX lines, to provide associated lines. The feature includes a choice of station number. The maximum number of multilane hunting groups shall be 250 with up to 500 lines per group.

p) Call Diversion: With this service, all calls directed to a subscriber line while busy or if not answered within 30-45 seconds are forwarded (diverted) to an alternate local destination: 0.5% of exchange lines.

q) Automatic Call Back: 0.5% of exchange lines.

r) Inward and Outward Dialing:

1. Direct Inward Dialing (DID): 2.5% of exchange lines.
2. PABX Direct Outward Dialing (DOD): 2.5% of exchange lines.
3. Total Exchange Capacity: 2.5% + 2.5% = 5% of exchange lines.

5.33.3 Optional Classes of Service

The following classes of service shall be available to the digital switching system, along with full details of methods, limitations, and required equipment, including additional processors if needed.

a) Automatic waiting (camp-on-busy) for Centrex.

b) Radio paging.

c) Automatic credit card.

d) Long-line subscriber (providing up to 3,000 ohm loop resistance by using different techniques, including extenders).

e) Conference call: 0.5% of exchange lines.

5.33.4 Rearranging of Service Features

The digital exchange shall be equipped with sufficient flexibility to permit alterations due to a change in service requirements. It shall be possible to rearrange classes of service, routing trunk assignments, and similar service options by command through input/output devices, or through modifications to the existing store programs. The required operating terminals to accomplish such modification shall be included as interfacing peripheral devices.

5.33.5 Call Restriction

Cal-barring capabilities shall be available and shall be activated by command, under the control of the administration only. The following classes of restriction shall be provided:

a) Trunk offering barred.

b) All outgoing calls barred.

c) All terminated calls barred.

d) LDD calls barred.

e) LDD and IDDD calls barred.

f) Access to certain operator services barred.

5.33.6 Non-Telephone Services

The digital exchange shall have the capability of handling non-telephone services as well, in order to form part of an Integrated Services Digital Network (ISDN).

5.34 System Software

5.34.1 General

The system software shall be designed to provide an efficient, continuous, reliable and stable service, throughout the digital exchange's life, while the system performance objectives are fully met. The system software shall include all on-line and off-line system programs, support programs, permanent data, semi-permanent data, and other variable data. The data are defined here as follows:

a) Permanent Data

Data that define network, system hardware and software address linkages, and tables.

b) Semi-permanent Data

Data that define exchange-dependent parameters that can be changed by man-machine commands.

c) Variable Data

Data that define subscribers conditions and the switching conditions at any point in time. These data are constantly modified and/or manipulated by software in response to changes in software and hardware conditions.

5.34.2 Software Configuration

a) Design Objectives

The software configuration shall be modular. Each module shall have a well-defined function with standard interfaces and procedures for communicating with other modules. Inter-module coupling shall be minimized to achieve modular independence. The modules shall be easy to add and to modify without interfering with modules in operation, and provide fault tracing and debugging capability. Sufficient memory space shall be reserved for program changes.

b) Types of programs

Call processing, maintenance functions, and the administration of the exchanges shall be under control of software. Programs shall include, but not be limited to, the three main categories shown below:

1) Operational programs

Such as system operating, call handling, fault recovery, diagnostic, maintenance and administration programs.

2) Installation testing programs

The installation testing programs shall provide testing capability for the system during the off-line installation, and during the on-line exchange expansion.

3) Supporting programs

The supporting programs will be necessary to support all kinds of software used in the on-line and off-line systems. The supporting programs shall have program tracing and debugging facilities to enable operating personnel to analyze program faults.

5.34.3 Man-Machine Communication Software

Man-machine communication software shall provide interface between the operation and maintenance software and the man-machine communication devices. Man-machine language (MML) used by the system shall follow ITU-T Recommendations. The man-machine communication software shall perform checks on requests from the operation and maintenance staffs for function to be performed, and ensure that all the data required to activate a function are correct. The man-machine communication shall be accomplished by means of commands from the visual display units with keyboards within the

exchange unit facility or at a remote location. The output message shall be in English, and not in coded format. Each message shall be clear, concise, and understandable by maintenance personnel who have had no special training in programming.

5.34.4 Backup Storage for Software System, and Programming Language

Backup storage shall be provided for all programs, permanent data and semi-permanent data. More than one medium of system program and data backup storage shall be provided.

High-level language shall be used in major or all parts of the digital switching system.

5.34.5 Information Required for Software Changes

All modifications and/or improvements generated by the manufacturer as part of product software upgrading, and all new capabilities, which are incorporated into the system, shall be offered to Saudi Aramco.

The manufacturer shall describe the methods used for updating the software of the exchange with new software versions developed by their software department. In particular, detailed answers are required to the following:

a) What arrangements shall be provided for the issuance of new software versions when improvements are introduced?

b) What changes in functional specifications, subsequent to acceptance of the system, shall be made on a joint basis between the manufacturer and Saudi Aramco?

c) How will the initial exchange data load be processed and how will it be updated?

d) Proven Software

The manufacturer shall indicate whether the provided software programs for a proposed exchange:

1. Have been proven in service in the same type of exchange as the one offered to Saudi Aramco, or

2. Shall be specially developed or substantially modified to meet Saudi Aramco's requirements or have been tested in the laboratory but have not yet been proven in the field.

Manufacturers shall provide information on pre-tested programs that describes the tests used, with supporting documentation.

5.35 Timing and Synchronization

5.35.1 National Interworking

The CO digital switching system shall allow the introduction of a fully synchronized digital network employing a master slave configuration.

At the highest level of the network hierarchy, a National Master clock of very high accuracy and stability shall be used as a reference for network synchronization purpose. Timing signals shall be distributed through the Integrated Digital Network (IDN), and until IDN is completed, the CO digital telephone exchange shall allow plesiochronous operation with the free run mode of its own exchange clock.

The second level of network hierarchy, i.e., the zone switching center and/or the group switching center, shall be equipped with clocks of lower standards than the master clock. These exchanges shall be synchronized to the international telephone exchange on a master slave configuration. In the event of failure or loss of the synchronization link for a particular exchange, synchronization shall automatically switchover to a stand-by synchronization link, which can be either from the international telephone exchange or from a zone switching center or a group switching center, acting as secondary master clock.

The third level of the network hierarchy, i.e., the local digital exchanges shall operate as a slave to their corresponding upper hierarchy levels.

5.35.2 International Interworking

The synchronized network is requested to operate, on a plesiochronous mode with other national digital networks in accordance with ITU-T G.811. The manufacturer shall ensure that, the design of the proposed digital exchange(s) for Saudi Aramco, are in compliance with ITU-T G.811, which states that, all clocks at network notes that terminate international links will have a long-term frequency departure of not greater than $\pm 1 \times 10^{-11}$. This is the minimum accuracy of stratum one (1) clock requirements. The National Master Clock (NMC) shall be collocated with the digital international telephone exchange.

5.35.3 Exchange Timing Distribution

The distribution of the timing within each exchange shall be such that the exchange maintains synchronism through the exchange. Furthermore, whenever it is required, the Remote Satellite Unit (RSU) and the Remote Concentrator Unit (RCU) shall operate synchronously with their parent exchange or RSU. The RSU shall be able to operate in free run when isolated from the parent exchange.

5.35.4 System Tolerance

The system shall accept phase deviations without the introduction of the slips and/or errors, within specified limits of "jitter" and "wander" according to ITU-T G.821, and G.822. In the event where, plesiochronous operation is introduced during the phase at which IDN is not completed, the system shall be equipped in such a manner as to accept phase deviations without the introduction of slips and or errors. The manufacturer shall state the accepted limits, and also shall state clearly the long-term accuracy and stability data of the proposed clocks at all levels of the network hierarchy. The average life expectancy of the clock oscillators, regarding system clock reliability, is 20 years.

5.35.5 Synchronization Loop

The CO digital exchange shall check and report any phase differences between the master and local clock signals, and shall detect and report slips, bipolar violations, and lost synchronization.

5.35.6 Redundancy

The CO digital exchange clocks shall present at least 1+1 redundancy with automatic changeover and without loss of synchronization in the event of failure. The manufacturer shall state the type of redundancy offered.

5.36 Distribution Frames

5.36.1 Main Distribution Frame (MDF)

The MDF shall be compatible with the specified digital switching system and protect the switching equipment from all abnormal electrical effects originated in the outside plant.

The MDF shall be designed to provide compatibility with the assignment system recommended for use with the specified switching equipment; convenient access for the placement and removal of jumpers; and a rapid, dependable means of securing reliable jumper

connections. The necessary terminal blocks required to accommodate subscriber lines and trunks shall be provided.

The MDF shall be of the miniature type, vertical, or an equivalent high- density protector frame with a separate cross-connect frame. The Vertical to Horizontal ratio for the MDF must be 1.6.

Vibration-resistant test shoe connectors shall be included to permit the connection of line-testing devices. Insertion of the test shoe connectors shall isolate the subscriber lines from the exchange equipment.

The following miscellaneous circuits (a), ground bus (b), and tip cables (c), shall be included with the MDF:

a) Miscellaneous Circuits

Means of extending external network circuits to test desks, fault-monitoring/locating equipment, and auxiliary test equipment. Any other circuits normally required at the MDF to implement standard features of MDF, Centralized Operation and Maintenance (COM) centers, and exchange equipment.

b) Ground Bus

MDFs shall be equipped with ground bus bars having the conductivity of a number 6 AWG copper conductor, or greater.

c) Tip Cables

Each terminal group on the MDF shall have a factory-assembled tip cable. Connectors shall be installed to the tip cables for connection to the entrance cable in the cable vault. Tip cables shall have the size of a number 24 AWG copper wire, individually insulated with polyethylene, and with a polyvinyl chloride outer jacket. Tip cables shall contain cable pairs in multiples of 25 pair-binder groups. Tip cables shall also have an 8-millimeter aluminum jacket between the core and outer jacket with a coating that provides bonding to the outer jacket. A suitable wrapper shall be used over the cable core to provide insulation between the insulated conductors of the core and the shield. The metal shield shall be connected to the main frame bus at the MDF. Tip cables shall have a certain number of meters in length depending on each individual side's requirements. Refer to SAES-T-243, SAES-T-903, SAES-T-920, and SAES-T-938.

With each MDF, the following shall be included:

1. A double quantity of jumper wire needed to place the exchange in full service.
2. A set of jumper wire dispensers.
3. Special tools required for jumper connections.
4. A full set of test equipment.

5.36.2 Digital Distriburion Frame (DDF)

All DDFs required for terminating digital interoffice trunks shall be provided complete with frames, jack panels, patching cords, and all necessary accessories as required.

5.36.3 Intermediate Distribution Frame (IDF)

All IDFs to be located at each exchange room to terminate all voice-grade circuits for miscellaneous use, if required, shall be provided complete with frames, terminal blocks, and jumper wires.

5.37 Transmission Parameters

The overall performance of the digital exchange communication equipment shall be verified by conducting a series of transmission measurements, per applicable standard methods and procedures, including the ITU-T Q.544 "Digital Exchange Measurements" and the SAES-T-521 "Circuit Measuring Techniques".

5.37.1 Analog Transmission

The CO digital switch shall conform to ITU-T G.712, Q.552 and Q.553, regarding the analog transmission.

a) Attenuation

For connection through the local exchange, the attenuation measured from MDF to MDF with 600 ohm, zero angle terminations shall be less than 0.5 dB at 800 Hz.

Variations in the attenuation in the frequency range 300-3400 Hz from the value at 800 Hz shall be less than ± 1 dB.

b) Return Loss (Transhybrid Loss)

300 to 500 Hz: greater than 14 dB.

500 to 2000 Hz: greater than 18 dB.

2000 to 3400 Hz: greater than 14 dB.

c) Harmonic Distortion

The harmonic distortion of any single frequency output between 200 Hz and 3400 Hz shall not exceed -40 dBm0 [with a test signal of 1004 Hz at zero (0) dBm0].

d) Intermodulation Distortion

The intermodulation products of two sine wave signals with frequencies of 740 Hz and 1255 Hz applied simultaneously, and with equal levels in the range of - 4 to -21 dBm0, shall not exceed -35 dB relative to any of those two input signals.

e) Noise

The psophometric long-range average noise power for any connection through the exchange shall not exceed 0.2 mV (MDF to MDF).

f) Idle Channel Noise

The idle channel noise shall not exceed 23 dBrnC on standard configuration.

g) Quantizing Noise

The signal-to-noise ratio shall not be less than 33 dB if a test tone of 1004 Hz with a level of -30 dBm0 is used.

h) Impulse Noise

Noise counts shall not exceed 5 counts in 5 minutes time period, at a threshold of -35 dBm0.

i) Crosstalk

1) Any two-wire connection through the exchange with 600 ohm, zero angle termination shall be greater than or equal to 67 dB.

2) Any four-wire connection between outgoing and return paths shall be greater than or equal to 60 dB.

j) Busying of Trunks without Transmission Facilities

A means by which trunks may be made busy when the transmission channel is not in service shall be available through programs that are initiated either automatically or manually.

k) Testing the Transmission of Routes

The following functions shall be available to test traffic routes and carry out transmission measurements:

1) Testing of calls originated from subscriber's line circuit to any B-subscriber by means of random selection of a transmission path.

2) Testing of calls originating from a trunk circuit to any B-subscriber with either random or individual transmission path selection.

3) It shall be possible to select one of the following methods of operation.

- Simple detection of identification sequence generated by associated equipment.

- Measuring of transmission loss on both paths by means of testing with a single tone in a local area, or by means of testing with three frequencies in a national area.

l) Noise Measuring

Means of noise measuring capabilities shall be provided, in order to make a printed record of the transmission path for which the level of transmission is either out of limits or out-of-service.

5.37.2 Digital Transmission

The CO digital switch shall have the capability to monitor continuously digital trunks and subscriber links. The continuous checks are required to ensure the availability of the links and to verify their quality by identifying bipolar violations, frame errors, slip rates and alarm patterns.

The switch shall provide an essentially zero loss network with a standard transmission level of zero (0) dB, through switchable pads under software control.

a) Transmission Bit Rate

The switch shall be capable of making available transmission channels, with different effective bit rates, depending on the application.

1. Basic Bit Rate

   The switch shall be capable of making connection between time slots with the basic bit rate of 64 kb/s.

2. Basic and Primary Rate Interfaces

   The switch shall be capable of making available the Integrated Services Digital Network (ISDN) with both 2B+D basic rate interface and 30B+D primary rate interface.

b) Bit Integrity

The paths through the switch shall not impose restrictions on the bit pattern. The switch shall be capable of maintaining bit integrity in 64 kb/s connections.

Error Performance

The long-term mean bit error ratio shall be $1X10^{-9}$, for a single pass of 64 kb/s connection (through a switch) between the digital transmission/switching interfaces.

c) Slips

A slip shall not occur in a synchronized switch network, if the jitters and wanders at the switch input remain within the limits given in ITU-T G.823 (the control of jitter and wander, on the 2048 kb/s). Under nominal operating conditions, only one slip in 70 days per interconnection will be acceptable.

5.38 Ringing Supply, Tone Supply, and Recorded Announcements

5.38.1 Ringing Supply

The digital exchange shall be equipped with duplicated or redundant ringing supply on a main and standby basis. Automatic changeover to standby shall take place on failure of the main unit, and an alarm condition shall be given when changeover takes place.

Ringing

Output voltage shall be 90 Vac at 20 ± 2 Hz. The cadence of the ringing cycle shall be 1 second on and 4 seconds off for local calls and 2 seconds on, 1 second off for long distance calls. The first transmission of ringing to the called line shall start write away, once it has been determined that the desired subscriber's line is free.

This can be achieved either by starting the first pulse of ringing of the cycle when the free line is detected, or by applying a single burst of ringing (of 1 second duration) followed by the random application of the ringing cycle.

The ringing signal shall be removed as soon as the called party goes off hook, regardless of whether the silent or ringing period of signaling applies at that time.

The ringer impedance shall be based on a maximum of four (4) telephones per line.

5.38.2 Tone Generation and Outpulsing

The CO digital switch shall have the capacity to generate 512 individual frequencies, which can be used to produce various distinct waveforms. All tones shall be digitally generated. The frequency and cadence of each tone shall be maintained within 0.5% of nominal value respectively. Provision for adjusting tone levels shall be included.

a) Dial Tone

Dial tone shall be transmitted (a) in response to a request for service from a calling subscriber, or (b) as a result of initiation of a custom service. It shall consist of a continuous signal at a frequency of 450 Hz modulated by a 50 Hz sine wave voltage with adjustable output, 80 to 100% modulation. The tone level shall be -12 dBm/600 ohms.

b) Ring-Back Tone

Rink-back tone shall be returned to the calling subscriber as an indication that the exchange has connected the call to the desired subscriber and that the line is free. It can also be returned on certain calls to operators and special services. It shall consist of a frequency of 450 Hz modulated at 50 Hz in the following sequence; 1 second on, 4 seconds off for local calls and 2 seconds on, 1 second off for long distance calls. The tone level shall be -12 dBm/600 ohms.

c) Busy Tone

Busy tone shall be returned to the calling subscriber if the desired subscriber's line is busy or all the lines belonging to a series of collective numbers are busy. It shall consist of a frequency of 450 Hz in the following sequence, 0.50 second on, 0.50 second off. Busy tone shall be returned from the subscriber's line circuit so that the transmission matrix is released when the busy condition is detected. Each tone level shall be -12 dBm/600 ohms.

d) Congestion Tone (Reorder Tone)

If a calling subscriber does not reach the desired subscriber due to congestion of equipment or unavailability of a trunk circuit group, the existing exchange shall return a busy tone to the calling subscriber. However, the digital system shall have the potential to provide a congestion signal having a different cadence from the busy signal, (to indicate to the subscriber calling, that there is congestion at the exchange or trunk group). Both congestion and busy tones shall employ the same frequency of 450 Hz. Each tone level shall be -12 dBm/600 ohms.

e) Pay-Station Tone

In case that might be required, the pay-station tone shall be an audible indication to the operator that the call is coming from a coin box. This signal shall consist of a burst of 950 Hz for 0.25 second, which is applied before the transmission path to the calling subscriber is completed. Tone level shall be -12 dBm/600 ohms.

f) Information Tone

Information tone shall be applied to the recorder announcements in order to indicate to the incoming international callers that, if they cannot understand the language of the recording, they should call their national assistance operator.

It consists of:

950 ± 50 Hz for 0.33 second followed by

1400 Hz for 0.33 second followed by

1800 Hz for 0.33 second followed by

silence for 1.00 second.

The signal cycle shall be applied before and after each announcement message. Tone level shall be -12 dBm/600 ohms.

g) Offering Tone

Offering tone shall be used to indicate to a subscriber that an operator will be connected into the conversation. It shall consist of three pulses of 950 Hz, 0.15 second on, 0.1 second off, followed by 0.15 second on, 0.1 second off, followed by 0.15 second on immediately before the transmission path to the operator is completed. The tone level shall be -16 dBm/600 ohms.

h) Intrusion Tone

Intrusion tone shall provide an indication to the parties of a call that an operator has connected to that call. It shall consist of a 0.5 second burst of 450 Hz, 0.5 second before and after the transmission path to the operator is completed. The tone level shall be -16 dBm/600 ohms.

i) Receiver Off Hook Tone (Howler)

Receiver Off Hook (ROH) shall be applied telephone lines which are timed-out because of the receiver being off the hook without a call being in effect. It shall consist of 1400 Hz + 1800 Hz for 0.2 second on, 0.3 second off in recurring cycle at a maximum level of +3 dBm/600 ohms.

j) Charge Interval Indicating Tone - (NOT NEEDED FOR A LOCAL SWITCH)

This signal shall be sent 12 seconds before the end of a charging interval. It shall consist of a burst tone of 950 ± 50 Hz which last for 0.25 second. The tone level shall be -16 dBm/600 ohms.

k) Vacant Code or Number Unobtainable Tone

This signal shall be applied to calling lines (without effecting a charge for this call). It shall consist of 450 Hz applied for 2.75 seconds on with 1.25 seconds off in a recurring cycle. The interval allows for the release of echo suppressors on long distance four-wire transmission circuits. The tone level shall be -12 dBm/600 ohms.

l) Call-Waiting Tone

A call-waiting tone is used only in conjunction with call-waiting service that allows a busy line to answer an incoming call by flashing the hook switch.

An audible ring is applied to the calling line and the call-waiting tone is applied to the called line.

Call-waiting tone shall be:

1. ***Tone A*** – 440 Hz + 480 Hz, one pulse of 1.0 second duration is sent to the wanted subscriber "A" if it is already engaged on a call.

2. ***Tone B*** – 350 Hz + 440 Hz, 0.25 second on, 0.25 second off, 0.25 second on, 3.25 seconds off is sent and repeated periodically to both talking parties "A" and "B" when a connection to one of them is required by another subscriber "C".

3) ***Holding Tone*** – 0.5 second tone A, 0.5 second break, 0.5 second tone B, 2.5 seconds off, repeated periodically, is sent to the second party "B" of the original call if it continues off hook after the wanted subscriber "A" has changed over to speak to "C".

m) Confirmation Tone

A confirmation tone is used to acknowledge receipt by exchange of information necessary for special services, including abbreviated dialing, call forwarding, do-not-disturb, etc. A confirmation tone shall be a tone of 350 Hz + 440 Hz, 0.1 second on, 0.1 second off, 0.3 second on.

n) Special Dial Tone

A special dial tone is returned to a calling party as a reminder that a certain class of service feature is being activated. The tone shall consist of three bursts of 350 Hz + 440 Hz, 0.1 second on, 0.1 second off, each, then steady on.

5.38.3 Recorded Announcements

The CO digital exchange shall include announcement equipment to store digital recorded messages. The announcement equipment shall

be connected directly to the digital switching network in the exchange. The announcements shall be accessible to both originating calls from local lines and terminating calls from lines located in other exchanges, also, it shall be possible to give announcements to called subscribers for special services, such as wake up service, etc. The exchange shall be capable of sending the same message to a number of subscribers or trunks, while the number of simultaneous connections shall not be limited.

The output level of any recorded message shall be, on average, -13 dBmO measured at the Main Distribution Frame (MDF) where the two-wire line is terminated. The output level shall not be affected by the number of subscribers or trunks to which the same message is being sent simultaneously. The CO digital exchange shall release the connection of the announcement equipment when the calling subscriber clears, and when the recorded message has been repeated two times. Upon release, the exchange shall send a busy tone to the calling subscriber or trunk. Announcement equipment translation and routing for at least sixteen (16) different announcements shall be available in each CO digital exchange.

5.39 Maintenance and Test Facilities

5.39.1 General

This section describes the operations and maintenance functions required for the efficient and reliable operation of the CO digital exchanges. Local operations and maintenance capabilities shall be provided in each exchange. The exchanges shall provide all required equipment and means necessary to interface/interact these functions with the centralized operation & maintenance facilities, which is the Saudi Aramco Network Operation Control Center (NOCC) located in Dhahran.

5.39.2 Scope of Maintenance Functions

The following automatic and semiautomatic capabilities shall be accessible from system consoles, both locally at the exchanges and centrally at the NOCC facility.

a) Administration of the exchange(s).

b) Exchange supervision and maintenance.

c) Outside plant supervision and tests functions.

d) Transmission tests and signaling system tests.

Testing and diagnostic capabilities shall be provided to systematically monitor the performance of the exchanges, to obtain operating status information, detect fault conditions, activate alarms, and identify faulty hardware and software modules. A description of standard on-line and off-line test facilities built into the exchanges shall be provided.

Diagnostic capabilities shall be provided to permit the identification of faulty units at the lowest level of readily replaceable hardware modules, such as individual circuit boards. After a part or parts suspected of failure have been replaced, the running of diagnostic programs shall determine, display, and print whether the trouble has been cleared or the unit is still faulty.

The output of the diagnostic tests of a faulty unit shall yield direct information as to the location of the failed circuit boards. For the infrequent case where a trouble or multiple troubles cannot be quickly located, the system shall provide the actual results of each diagnostic test or specific subsets of tests.

The diagnostic programs shall not interfere with the normal call processing programs or system operations. The testing and diagnostic functions shall include, but not be limited to, those normally associated with "test desk" functions, such as the following:

a) Extension of the testing circuits toward both the subscribers' lines and the exchange equipment.

b) Identification and location of reported faults.

c) Dial-speed testing and DTMF testing.

d) Ringing testing.

e) Verification that the line is connected to station equipment.

f) Testing subscriber line loop resistance and insulation resistance.

g) Transmission testing.

h) Testing for extraneous potential.

5.39.3 Administration Functions

The administrative functions required at each exchange are those needed to retrieve status information and control the operation of the exchange. Such functions involve database manipulations, including entry of data, day-to-day modifications (i.e., provisioning, etc.), entry of commands, as well as the retrieval of information to verify loads, to make modifications, and to validate changes.

a) Entry of Data Fields

Entry of data fields shall be made via system consoles and other local and remote data processing peripherals, such as magnetic tape units. The kinds of data to be entered involve the allocation or assignment of facilities, and instructions to the system regarding its internal operations, its interaction with other exchanges. All input and output messages used for maintenance and test facilities shall conform to ITU-T Recommendations on man-machine language.

Data assignments shall include, but not be limited to, the following:

1. Directory numbers to subscribers' lines.
2. Calling classes of service for lines and incoming trunks.
3. Called classes of service for lines and outgoing trunks.
4. Lines to hunting groups (PABX).
5. Type-of-service categories to incoming lines and trunks, i.e., maintenance, coin boxes, etc.
6. Addresses to trunk groups using the same route treatment.
7. Type-of-service to outgoing trunks, i.e., PABX or DID.
8. Digit deletion or addition to incoming or outgoing trunk groups.
9. Service circuits.

b) Day-to-Day Data Modification

Operations personnel shall be able to modify or add new data, either from consoles. This standard feature will be used for day-to-day operation of the system and will allow for:

1. Adding new subscribers.
2. Removing subscribers.
3. Call interception.
4. Number changes.
5. Adding or deleting trunks or trunk groups.
6. Modifying call routing.
7. Service class change.

The system shall also have the capability of providing all relevant data associated with line records as part of the database.

c) Initialization or Replacement of Database

The means employed for initializing the database during installation or re-initializing it a fault shall be described in detail. This information shall describe the procedure used, the storage methods, and the duration of procedure.

d) Integrity of Database

The methods employed to ensure that the required data are, in fact, entered into the memory areas of the equipment and are protected once entered, shall be described in detail.

e) Report Generation and Data Retrieval

Upon request from keyboard, the system shall provide system status reports and retrieve specified data files on a VDU and/or printed copy.

f) Traffic Measurement

The system shall provide for the control and retrieval of traffic measurement information. At the option of the console operator, output data shall be made available in the form of a display, hard copy and/or stored on tape or disc.

5.39.4 Exchange Maintenance

a) Traffic Performance Supervision

Traffic performance supervision shall include the following:

1. Supervision of quality of originating traffic sources. This is required to verify that at least one call is made through each originating traffic source (i.e., line unit or trunk group) in the exchange during a predetermined period.

2. Blocking supervision. This is required to establish that the number of blocked services on certain routes does not exceed the predetermined limit value for the grade of service.

3. Supervision of faults. This is required to detect and indicate which traffic-carrying units, functional units, and routes through an exchange are not operating properly. This will indicate the number of faults, the time and status of the call when the fault occurred and whether there was a failure after a second attempt to complete a call. If the number of faults exceeds a predetermined value, an alarm must be actuated.

4. Supervision of the digital switching network is required to determine that the number of blocked connections does not exceed the predetermined limit.

5. Supervision of processor loading. This is required to prevent interruption of service due to overloading the processor. Hence, it must be possible to control the intensity of the traffic in the processor by reducing overhead programs, reducing time-out intervals, and increasing line-scanning intervals.

6. Verification of the transmission path through the digital switching network. This is required to establish calls from specific inlets toward specific outlets through the switching network and, also, to control specific switching points of the switching network.

7. Tracing the transmission path of a call. This is required to identify the elements involved in a specific connection. Tracing can be initiated either by an instruction or automatically by means of a diagnostic program.

8. Inhibition of disconnection. This is required to stop release time-out on demand, on a specific connection to allow the continuation of a connection, i.e., in which a signaling failure or release time failure has occurred.

b) Testing with Traffic Equipment

Test calls shall be set up and checks shall be made at different phases of the test calls. When a fault occurs, the connection shall be held and the location of the fault indicated. It shall be possible to make test connections between two groups of test numbers for checking and recording transmission levels, metering, ringing signals, insertion loss, crosstalk, etc. It is not required to provide tests on the external line plant or subscriber errors; the success or

failure of call made with this capability will be entirely dependent on the condition of the exchange equipment.

c) Maintenance Actions

When a malfunction has been detected and an equipment fault isolated, the system software diagnostics shall provide sufficient information, available at the local console and at the Saudi Aramco Network Operation Control Center (NOCC) facility's console, to direct a craftsperson to the faulty circuit boards.

Following replacement of the faulty unit, system diagnostics shall validate the successful completion of the maintenance action.

The system shall provide information by the rank order, indicating the percentage of faulty events in which faulty equipment can be localized to only one circuit board; to two circuit boards; to three circuit boards; and so forth.

d) Other Equipment

Maintenance methods and routines shall be described, and test equipment shall be included for all other equipment such as batteries, rectifiers, diesel generators, and HVAC. Actions to be taken by maintenance persons shall be described in response to the operation of the alarm indicators and sensors from such equipment.

5.39.5 Outside Plant Supervision and Test

a) Checking of Line from Subscribers' Premises

In addition to making tests with the cooperation of the wire chief, the repair person shall be able to check the condition of the line from the subscribers' premises by dialing special access codes, via a telephone set. These codes shall provide, as a minimum, the following tests:

1. Measurement of voltage on the line.
2. Insulation resistance of wire "a" to wire "b" and of wire "a" or "b" to ground.
3. Measurement of loop resistance. (The limit value of loop resistance is 2000 ohms (maximum), including the telephone instrument, 1900 ohms is acceptable).
4. Dial speed test.

5. Telephone instrument ringer test.

6. DTMF test.

7. Verification of correct directory number. A repair person(s) at subscriber stations shall be able to report to the exchange maintenance center or NOCC facility by dialing a code.

b) Tests Made Before Completing a Call

Automatic subscriber line tests shall be made to verify the absence of extraneous voltages on the line. These tests shall be made automatically on the lines of subscribers A and B during the establishment of the call. If a line condition precludes the extension of the call to or from one of the subscribers, the relevant lines shall be "busied-out", and a record of the fault shall be made. Such lines shall be automatically checked for correction of the condition.

c) Local Test Positions

Each exchange shall be equipped with more than one test position to provide all the functions listed below in this sub-section. Each position shall be able to test both the subscriber's lines and the exchange equipment.

It shall be possible to exercise, at a remote centralized test center, all functions performed at the local test positions. All necessary equipment capable of performing these tests in a remote place, shall be furnished. The functions provided shall include the following.

1. Measuring resistance: Measure the two-terminal DC resistance a-to-b, a-to-ground, or b-to-ground.

2. Measuring capacitance: Measure the two-terminal capacitance a-to-b, a-to-ground, or b-to-ground.

3. Distance to an open circuit: Measure the line capacitance to determine the distance to an opening on a line.

4. Line circuit test: In order to test the line battery and verify that dial tone can be received.

5. Rotary dial analysis: In order to measure the pulse count, dial speed, and the percent of break.

6. Speaking and ringing circuits: Apply a ringing voltage to a line with the receiver off-hook to verify that the ringer works.

7. An interrupted earth key for connection of interrupted earth to ground.

8. Remote test facilities.

9. Balance test: In order to determine if an attached line is balanced or unbalanced.

10. A howler circuit, or "receiver off-hook" tone injection, that allows the attendant to manually request that howler or equivalent tone be applied to the line.

11. Automatic and/or manual test call generation, to check dial tone, DTMF/DP reception ringing, ring trip, and two-way transmission.

12. Cable fault alarm.

13. Measuring foreign potentials: Measuring the potential of an AC or DC source present at the a-to-b, a-to-ground, or b-to-ground terminals.

14. Other standard test facilities, including new subscribers tests, tone demonstration, outgoing lines to both DP and DTMF telephone sets, and night alarm and trunk circuits.

15. Coin line test facilities (if required), for application of coin return, coin collect voltages, and reverse battery.

16. Possibility of connecting two headsets.

5.39.6 Blocking of Equipment

It shall be possible to block traffic-carrying units or functional units of the exchange(s), either manually or automatically, by means of instructions entered at the console, in order to isolate them from normal call processing, so that they can be part of a desired test connection.

5.39.7 Alarms

The switching equipment shall include audible and visual alarm systems to alert maintenance personnel of trouble conditions, or of imminent equipment failures. The alarms shall give maintenance personnel information on the nature of the trouble, its severity, and the location of the malfunctioning component. It shall be possible to extend or transfer alarm signals to the NOCC facility. Audible alarm signals shall be suppressible when a reported fault is being addressed by maintenance personnel. However, visual alarm signals shall be cancelable only when the fault has been cleared. Audible alarms shall have a cut-off key.

The visual and audible alarms signals shall indicate the type of fault, whether it is prompt or deferred and its location, and shall be classified according to the following levels:

a) Critical Alarms

These alarms indicate faults that effect adversely the operation of the exchange (service interruption) and need immediate action, such as:

1. Fire in switching room.
2. Blown major fuses or tripping of main circuit breaker.
3. Processor failure.

b) Major Alarms

These alarms indicate faults that partially impair service and may interrupt service to a group of subscribers and need immediate response, such as:

1. Ringing current failure.
2. Failure of battery charger.
3. High or low battery voltage.
4. Failure in alarm sender.
5. Failure in peripheral devices.

c) Minor Alarms

These alarms indicate faults that do not result in interruption of service, but that should be corrected as soon as possible, such as:

1. Service circuit time out.
2. Permanent loop.

3. Failure in HVAC.

Extension of alarms: The extension of alarms to a remote center may be through the interconnection link with each exchange, as well as independently. In either case the utilization of a dedicated digital link per exchange is required, through which a minimum of twenty (20) types of alarms will be transmitted.

Alarm details: Alarm reports shall include the name of the exchange from which the alarm originated, the type of alarm, the time of occurrence, and the time the fault was corrected.

5.39.8 Tools

Sets of tools and instruments necessary for the operations and maintenance of the digital exchanges, shall be provided in adequate quantities, per detailed design, for each exchange.

5.39.9 System Recovery

In case of hardware failure, the system shall automatically reconfigure itself into a working system without intervention of maintenance personnel. The exchange shall have the capability of initiating an on-line stand-by recovery program to recover the system on line without interrupting the service. The exchange shall have manual configuration capabilities to override the automatic recovery capabilities. After recovery, the exchange shall provide a record of all recovery actions (both automatic and manual). In the case of automatic recovery, the recorded data obtained shall allow analysis of the fault condition. A history of these recovery actions and the associated data shall be maintained in the exchange. A manual control shall also be included to initialize all call memory in the system.

5.39.10 Call Monitoring

The exchanges shall be designed in such a way that will allow the monitoring of all calls in process of connection. On demand it shall be possible to identify problems with any call that should become ineffective. Upon identifying the call in the fault state, the system shall automatically print out the appropriate indications of the call's state. It shall also indicate the circuit involved (trunk, register, line, etc.) to facilitate dispatching of maintenance personnel.

5.39.11 Information Requested

The following information, on maintenance and test facilities, shall be provided by the manufacturer.

a) Means used for initializing the database during installation or its re-initialization after a fault. The information required shall include procedures, methods of storage, and duration of the procedures.

b) Method used to ensure and to verify entry of data into memory areas.

c) Method used to protect data entered into memory areas.

d) Specific categories of data fields and types of reports generated by the maintenance system.

e) The method of processing alarm information; the type and number of alarms, and the triggering causes of each alarm.

f) Estimated cost maintenance of system, expressed in man-hours, per line, per annual.

5.40 Reliability

5.40.1 General

Saudi Aramco requires that the CO digital switching equipment shall operate with a very high degree of reliability. The effective performance of the telephone exchange is depended on its product specific properties as well as on the properties regarding the operational, environmental and maintenance conditions under which it is used. The objective of this section is to assure that systems meet satisfactory reliability performance standards without imposing undue constraints on the design of the system.

Reliability involves redundancy of hardware so that failures of individual components do not cause widespread failure, together with software and operating systems that enable the system to take proper action to overcome faults.

The design of the system shall include reliability features, including redundancy as appropriate in all functional subunits. Equipment of vital importance shall be duplicated. It shall be possible to estimate the annual failure rate of the total volume of components of a local exchange by means of a formula that incorporates the number of subscribers, total number of trunks and other parameters.

Since the reliability performance of a switching system is a function of the specific system architecture, the manufacturer shall explain how his reliability predictions were analyzed and calculated.

A block diagram representing the specific system architecture with all blocks named, shall illustrate the failure relationships between them, the failure probabilities for each block, and a representation of overall system reliability.

Maximum acceptable values are given in the following table:

Expected Value	Maximum
Total exchange outage Continuously, in 20 years of operation, for attended exchanges	1 hour
Cutoff calls in the calling state	1 per 10,000
Cutoff calls in the dialing and pre-connection state	6 per 100,000
Individual trunk or subscriber line Incapable of providing service	30 minutes per year
Incorrectly charged call	1 per 10,000

Details of faults that could cause degradation in service to one-half or more of all served subscribers shall be provided. Switches shall be designed to include safeguards and checks against possible incorrect actions by the maintenance staff, particularly during system reconfiguration. The details of these safeguards and checks shall be clearly explained.

5.40.2 Mean Time Between Failure (MTBF)

The expected maximum monthly circuit board replacement rate shall be one (1) circuit module per 1000 subscribers per month. Hardware maturity shall occur within the first twelve (12) months of service or six (6) months after final acceptance of the system.

The hardware's expected Mean Time Between Failure (MTBF) shall not exceed 1.6/n months (with "n" equal to the number of subscriber lines in the CO digital exchange divided by 1000).

5.40.3 Mean Time To Repair (MTTR)

The manufacturer shall indicate the mean time to repair a fault, based on the availability of spares at the rate he proposes and the location of the fault in relation to:

a. The location where the spare parts are available.

b. The location of the personnel necessary to identify and repair the fault.

5.41 Power Supply

All CO digital exchange equipment requiring direct current shall be designed to operate at a nominal -48 Vdc. The power system shall have sufficient capacity to serve the common control equipment, the number of lines, trunks and the traffic specified for each exchange. Batteries, rectifiers, dc power control, and dc and ac distribution equipment (including standby diesel generators) shall be included.

For power supply telecommunication equipment's specifications, refer to the various applicable documents, and to the following Saudi Aramco's standards, and materials system specifications:

SAES-K-511	*Diesel Engines*
SAES-P-100	*Basic Power System Design Criteria*
SAES-P-103	*Direct Current and UPS Systems*
SAES-T-151	*Communication D.C. Power System*
17-SAMSS-511	*Stationary Storage Batteries*
17-SAMSS-514	*Battery Charger/Rectifier*
17-SAMSS-518	*Diesel Generators*

5.42 Network Management

Networks, which are engineered to handle a normal traffic load, can quickly become overloaded when there is an unusual increase in subscriber calling or loss of capacity, or both. Network management is the function of supervising these networks, on a real-time basis, and taking action to control the flow of traffic. This shall ensure the maximum utilization of network capacity in all situations.

ITU-T E.410 shall be met. In additions, observance shall be made of current amendments.

5.42.1 Applications

The objective of network management requires a "systems" approach which looks not only at the performance of individual network components but also the performance of the network as a whole. Thus, it shall be possible for the new exchange(s) on all levels in the network (local, combined, transit, and international exchanges) to provide basic

network management functions as recommended by ITU-T. These functions shall be designed for local and/or centralized network management, covering the following areas:

a) Network performance information and reporting.

b) Network management controls.

The network management functions shall be designed to suit various structures of network management organization and level of operation.

Local and/or central staffing and operation with central operation is understood to be the operation of a number of exchanges from one center like the Saudi Aramco Network Operation Control Center (NOCC) facilities in Dhahran. The NOCC facility shall be upgraded in order to incorporate constant changes within the Saudi Aramco network, necessary for the expansion, upgrade and/or replacement of any existing equipment in the network. In the case of central operation it shall still be possible in failure situations to perform network management activities from a back-up point.

5.42.2 Preparations for Future Requirements

The functions provided, by the digital exchange, shall be prepared for smooth conversion to future automatic network management on a broad basis. This regards both the information part and the traffic flow control part of the functions. The preparations shall include possibilities for common channel signaling systems, i.e., ITU-T Recommendation Signaling System Number 7, to be used for carrying network management signals.

5.42.3 Network Performance Information and Reporting

To meet the requirements for local and/or central operation, a number of network performance information and reporting functions shall be provided by each exchange. The following information, as a minimum, is required:

a) Call attempt rate and traffic on each incoming route and for the whole exchange.

b) Grade of service of local and trunk calls that is being achieved.

c) Proportion of calls which are delayed beyond the stated limit.

d) Traffic and call attempt rate on outgoing trunk groups.

e) All Trunk Buses (ATBs) occurrences and durations.

f) Any action that the system has taken, in response to its call processing program, to reduce its traffic load.

5.42.4 Network Management Controls

Ordinary traffic routing follows a preprogrammed fixed routing pattern, normally an "alternative routing" program. This routing copes with standard dimensioned traffic load fluctuations. Network management controls temporarily override the ordinary routing to regulate abnormal traffic flows. It shall be possible to administer the network management controls in a uniform and effective way to meet network management objectives.

Commentary Notes:

Consideration shall be taken to guarantee safe temporary routing changes by authorized personnel.

The control shall be able to operate on:

(a) Traffic resources through percentage control, i.e., restriction or addition of accessible circuits.

(b) Outgoing traffic flow through percentage control (blocking a percentage of calls) or call gap control (minimum time interval between transmitted calls).

It shall be possible to direct rejected calls to special recorded announcements advising subscribers (and operators) to take appropriate actions.

5.43 Documentation

The manufacturer shall provide documentation to be used by planning, installation, operation, maintenance, administration and training staff.

Commentary Notes:

All documents shall be submitted in accordance with a schedule consistent with the training and installation programs as part of the Project Implementation Plan (PIP).

Should changes be needed to any documentation during the installation, revised documentation shall be supplied for inclusion in each of the reference and exchange sets. If copies of the revised documents cannot be made available in final form when needed for the installation activities, marked-up copies of the exchange set shall be supplied before the installation work proceeds. These copies shall be replaced by documents in final form before final acceptance.

5.44 Training Program (if required)

The manufacturer shall provide a program for training Saudi Aramco personnel on all equipment associated with the offered systems.

Commentary Note:

The manufacturer shall submit the following items in writing for approval by Saudi Aramco prior to commencement of training:

a) Syllabus and duration of required courses.

b) Performance objectives for each course as well as for the overall training program and related performance measurement criteria.

c) Pre-entry requirements (knowledge and skill levels) to be applied in selecting trainees for the courses at each stage in the training program.

d) Number of people expected to become skilled in each skill category (after allowing for an attrition factor during training).

e) Places where the manufacturer intends to provide training.

f) Training schedule.

6 Fabrication and Installation

6.1 The instructions issued by the manufacturer(s) shall be followed unless specific exceptions or deviations are noted in writing and/or on the installation / construction drawings. During the installation, the manufacturer(s) instructions shall also be followed and complied with, to avoid the possibility of violating manufacturer's equipment warranty conditions.

6.2 The manufacturer/contractor shall have full responsibility for fabrication, delivery, installation, and testing, of the offered CO digital switching and associated equipment.

6.3 The manufacturer/contractor shall follow proper guidelines for standard safety procedures during fabrication, delivery, installation, testing, cutover, operation and maintenance. The installation of Central Office (CO) equipment shall comply with this standard, SAES-O-100 (General Requirements for Safety and Security), the National Electrical Code, National Electrical Safety Code and other referenced and applicable standards and specifications.

7 Testing and Inspection

7.1 General

Acceptance shall consist of tests and inspections conducted on the CO digital switching system in-factory and on-site according to standard measurement and

test procedures. The acceptance, unless otherwise specified in writing, shall be conducted in the following stages:

7.1.1 Factory Testing

The factory testing has the aim of demonstrating the proper operation of functional subsystems. Saudi Aramco will have the right to be present at the factory during the testing of the equipment before shipment.

The manufacturer/contractor shall notify Saudi Aramco one (1) month in advance of the testing schedule to enable Saudi Aramco to send its authorized representative(s) to observe the testing of the equipment.

If Saudi Aramco does not send its authorized representative(s) at the specified time, the manufacturer/contractor can ship the equipment, provided it submits to Saudi Aramco a copy of the recorded tests performed in the factory.

7.1.2 Inspection on Delivery to Site

These inspections ensure that all items have been delivered to site without damage.

7.1.3 On-site Testing

On-site testing has the aim to demonstrate the proper operation of the CO digital switching systems.

7.2 Test Plans

The manufacturer/contractor shall propose a comprehensive acceptance test schedule, provide detailed testing procedures and record the results at each stage of the acceptance testing for the use of its own and Saudi Aramco's staff.

The test plans shall include a description of tests to be conducted, identification of test equipment required, amount of data to be recorded and criteria for evaluation.

7.3 Pre-Cutover

Pre-cutover tests shall be conducted by the manufacturer/contractor to demonstrate the readiness of offered equipment for cutover. Such tests shall demonstrate to Saudi Aramco the capability of the offered equipment to meet the requirements of this technical specification, including functional and load tests as specified in sections 7.5 and 7.6, which are part of the pre-cutover tests.

In addition to the tests, which demonstrate the proper operation of the system under normal operating conditions, tests shall be performed to demonstrate the capability of the offered equipment to perform under non-nominal conditions, including emergencies. Fault conditions shall be introduced to demonstrate the performance of system diagnostics and maintenance routines, including the introduction of simulated fault conditions to check the redundancy system which necessitate the automatic switchover of standby call processing systems for system recovery. Other tests shall demonstrate proper performance under public utility AC power outage conditions, including the performance of the standby AC power system (diesel generators) and the reserve power arrangement (batteries). The manufacturer/contractor shall generate a report documenting the pre-cutover test results for Saudi Aramco's approval prior to cutover.

7.4 Equipment Appearance Inspection

This section provides a checklist to verify that the installed Central Office (CO) digital switching equipment, meet basic quality standards for "fit and finish" details.

a) Alignment of equipment frames.

b) Mounting fixtures.

c) Mechanical operations.

d) Operation of cabinet doors.

e) General hardware components.

f) Cabinet surfaces.

g) Cabling and wiring.

h) Workmanship of wiring on distribution frames (MDF, DDF, and IDF).

i) Neatness of cable dressings.

7.5 Functional Tests

A functional test shall be conducted to demonstrate the ability, of the system's hardware and software, equipment components and modules, to correctly perform the service functions specified herein. Operational tests shall be performed to exercise all circuits and circuit components to ensure their proper functioning. End-to-end circuit tests shall be conducted to ensure continuity and transmission levels.

7.6 Load Tests

Software and hardware generated load testing shall be conducted to demonstrate the ability of the system to perform without degradation under the effective

maximum load of traffic. The load tests shall not be conducted until after the functional tests have been successfully completed.

8 Certification and Acceptance

8.1 Cutover and Provisional Acceptance Tests

Cutover is defined as the date on which an exchange and supporting offered equipment is put into service to carry live, revenue-bearing traffic. A successful cutover is defined as having occurred when the offered equipment has been in operation for seven (7) consecutive days after cutover, generally in accordance with the technical specification and without a major fault condition. A major fault condition is defined as one which causes a disruption of operation affecting more than one percent (1%) of subscriber lines or trunks for a period in excess of one (1) hour, due to improper, functioning of the offered equipment.

Following a successful cutover, provisional acceptance tests shall be conducted, by the manufacturer/contractor to demonstrate to Saudi Aramco that the offered equipment is performing in compliance with this technical specification.

As part for these tests, light-load and busy-hour load tests shall be conducted to demonstrate that test calls or live traffic calls selected for test purposes shall be properly switched to terminations with less than 0.01% faults under no load and less than 0.5% faults under busy-hour loads. Full functional tests, as specified in section 7.5 above, shall be conducted in such a way as not to interfere with revenue-bearing traffic.

Upon successfully completing the provisional acceptance tests, the offered equipment shall qualify for provisional acceptance following a period of at least thirty (30) days of continuous system operation without any major fault conditions. The results of provisional acceptance tests shall be documented and submitted to Saudi Aramco for approval, prior to the issuance of the certificate of provisional acceptance. The manufacturer/contractor shall be responsible for maintaining the equipment, including the replenishment of spare parts as required, during the period prior to the issuance of the certificate of provisional acceptance.

8.2 Final Acceptance Tests

Final acceptance tests shall occur no earlier than ten (10) months following the issuance of the certificate of provisional acceptance. Tests, similar to those conducted during provisional acceptance testing, shall be performed to verify that the technical specifications are being met. Full functional tests shall be performed with all types of calls tested. No more than 0.5% faults under busy-hour load conditions will be acceptable.

The vendor of the Central Office (CO) equipment and associated products is required to certify that the equipment delivered meets ITU-T specifications. If and where applicable, the vendor shall also certify that the equipment shall be modified to comply with future enhancements of ITU-T Recommendations through upgrade or replacement.

Final acceptance of equipment shall occur after the above conditions have been met, provided that the equipment has experienced no major fault condition for a period of 12 months, during the warranty period.

8.3 Trouble Log

A system log shall be maintained to record all system malfunctions and the actions taken to restore proper functioning during the warranty period.

Revision Summary

31 March, 2004	Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with minor revision.