NRSC

Power Outages Study Group

- Executive Summary -

August 29, 2002

"We had one or two power cuts while you were away, Gerald. I'm afraid you were one of them.

NRSC Study Group – Power Outages: Agenda

- **Team Membership**
- **Team Charter**
- **1996 & 2001 Power Outage Summaries**
- **Recommendations**

NRSC Task Group Members - Power Outages

Jay Bennett/Telcordia

Rick Canaday/AT&T

Jim Lankford/SBC

Karl Rauscher/Lucent

Jim Runyon/Lucent

Special "Thanks" to Jay Bennett (Telcordia), Bill Klein (ATIS) and Steven Perry (ATIS) for providing the data necessary for which to complete this study

NRSC Power Outage Study Group - Charter

- Original Charter:
  Investigate the Power Outages in order to determine:
  - » Root cause(s)
  - » Identify existing Best Practices that, if implemented, might have prevented the outages
  - » Report to the Committee about recommendations to reduce the number of Power Outages

- **<u>Modified Charter</u>**
  - **Compare the "1996 NRSC Power Study" and the "2001 ATIS Annual Report - Power Outage subsection"**
  - **Determine similarities/differences**
  - **Report findings and recommendations to the Committee**

POWER STUDIES: 1996 and 2001

1996 NRSC Power Study ('92-'96)

- Outages show an Upward Trend within the Green Zone
  - Normalization for the number of offices not included
- Alarms Impact on Outages
  - ~50% of Outages had Alarms indicated
  - ~50% of Power Outages had an Alarm Issue
- Recommendations
  - Seven Areas for new BPs
  - Statement of Importance of Alarms

2001 ATIS Annual Report ('93-'01)

- Outages show a *further* Upward Trend within the Green Zone
  - Normalization for the number of offices not included
- Additional Analysis of Alarms on Outages ('96-'02)
  - 31% of Outages had Alarms indicated
  - 10% of Power Outages had No Alarms
  - 59% of Power Outages had NONE INDICATED for Alarms

"The importance of power alarms can hardly be overemphasized if catastrophic power failures are to be driven to zero"

"Network Reliability: The Path Forward," April 1996. ATIS report; and
1996 NRSC Power Study: "Analysis of Power Related Network Outages," August 29, 1996

Power Outage: Summary

Findings

- NRIC Best Practices have been adopted for both POWER and ALARMS
  - 65 BPs for Power
    - » Covers all the Best Practice "key words"
  - 14 BPs for Alarms
    - » Covers all the areas recommended by the "1996 NRSC Power Study"
- The Industry is Aware of these Best Practices

Areas of Concerns

- The number of Power Outages continues to rise
  - Battery Distribution Fuse Outages (e.g., shorts, surges)
  - Low Battery Discharge Alarms
  - Outages caused during Routine Exercises
- No official mechanism to monitor whether Power Alarm BPs are being met

Recommendations – Power Outage Study Team

- **Recommendations to the NRSC Committee**
  - **Communicate to the Industry the importance of the Power and Alarms Best Practices; include the following points:**
    - » **Power Outages are increasing at annual rate of 12%**
    - » **The existing BPs effectively cover the vulnerabilities associated with Power and Alarms**
    - » **Experience has shown that BPs, when emphasized, resulted in improvement**
    - » **Focus on Alarms to ensure that Alarms BPs are implemented**
    - » **When collecting data on power outages, note whether a power alarm was presented and responded to in a sufficient amount of time; including such information in reports would help the NRSC better understand the contributing factors for these events**
  - **NRSC should continue to monitor Power Outage frequency and revisit the need to study as necessary.**
  - **Provide a WEB based "FCC Service Disruption Reporting (SDR) Form"**
    - » **Allows the greatest opportunity for consistent data collection**
- **Further Action**
  - **No further action for this Power Team.**
  - **Mission completed as per charter**

NRSC

Power Outages Study Group

- Detailed Report -

August 29, 2002

Executive Summary - Highlights

- Issue Identified

  Power Outage issue was raised at the NRSC quarterly meeting (3/02)

- Charter
  - Compare the “1996 NRSC Power Study” and the “2001 ATIS Annual Report - Power Outage subsection”
  - Determine similarities/differences
  - Report findings and recommendations to the Committee

- Task Group Recommendations to the Committee
  - Communicate the findings to the industry
  - NRSC should continue to monitor Power and Alarm related outages
  - Implement Outage Reporting via Web

- Further Action
  - None. Mission completed as per charter

NRSC Task Group – Power Outages: Agenda

- **Team Membership**
- **Team Charter**
- **1996 & 2001 Power Outage Summaries**
- **Recommendations**

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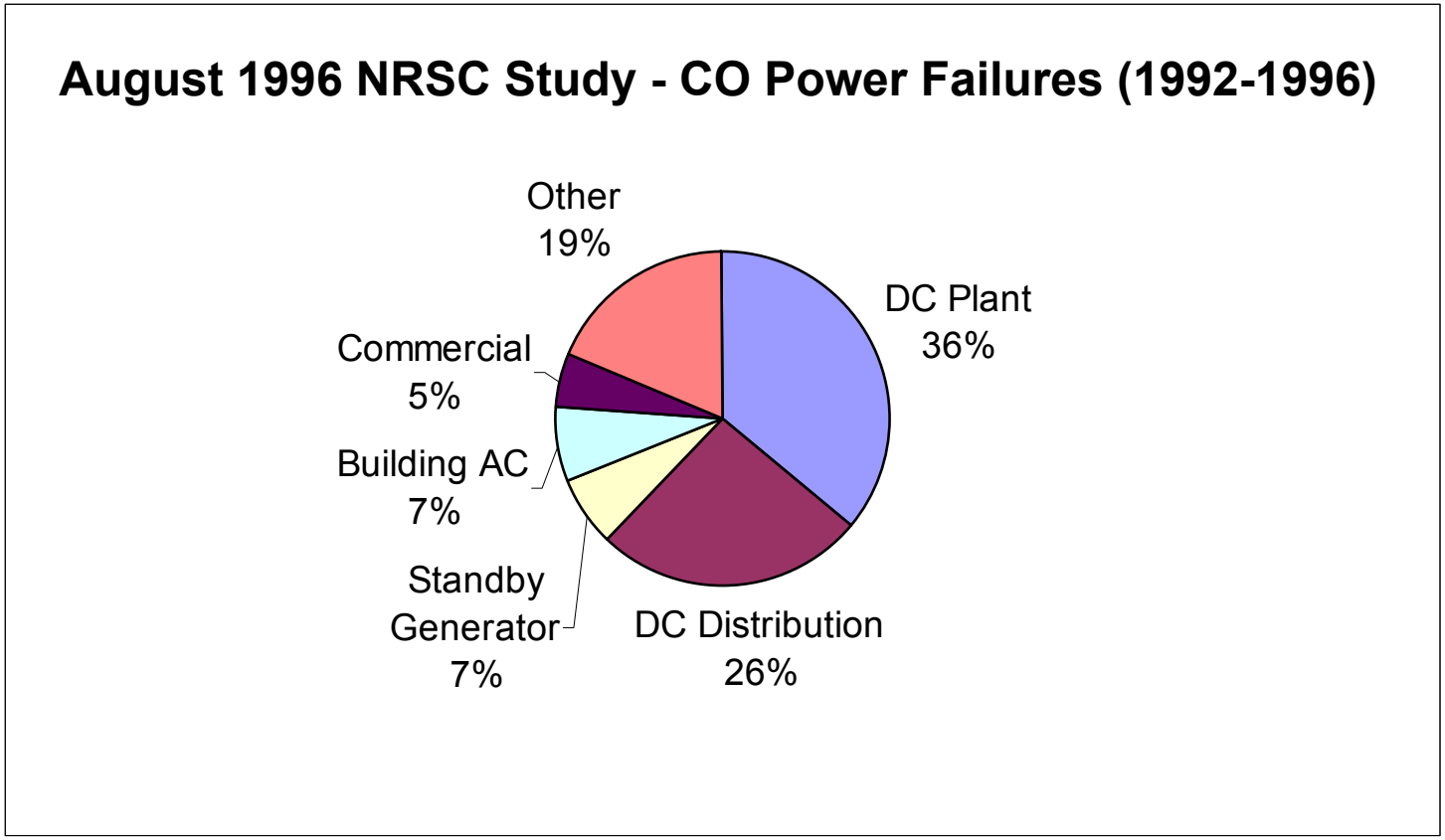
POWER OUTAGE - SOURCES

- **1996 NRSC Power Study: "Analysis of Power Related Network Outages," August 29, 1996**

- **ATIS, "State of the U.S. Telecommunication Networks and Root Cause Analysis: 2001 Annual Report," Jay Bennett/Telcordia, May 29, 2002**

1996 NRSC Study – CO Power Failures



- **Power failures showed an upward trend within the 'Green' Zone.**
- **Power Alarms were the underlying cause of more than half of the power outages**
  - **The lack of alarms**
  - **The malfunctioning of alarms, or**
  - **The inadequate response to the alarms**

POWER ALARMS

"The importance of power alarms can hardly be overemphasized if catastrophic power failures are to be driven to zero"

"Network Reliability: The Path Forward," April 1996. ATIS report

Findings from the 1996 NRSC Power Study

- **Each company must have an alarm strategy that ensures that power problems are promptly identified and addressed. Initial provisioning, ongoing maintenance, and alarm response must be integrated. (NRIC VI BPs: 5-514, 5-517, 5-527, 5-602, 5-637, 5-650, 5-662, 5-674 5-688)**

- **Provide a separate "battery discharge" alarm for all battery plants. Arrange the alarm to repeat every 15 minutes. (NRIC V BPs: 5-689, 5-691)**

  - **Redundancy must be provided so that no single point alarm system failure will lead to a battery plant outage. (NRIC V BPs: 5-690, 5-691)**

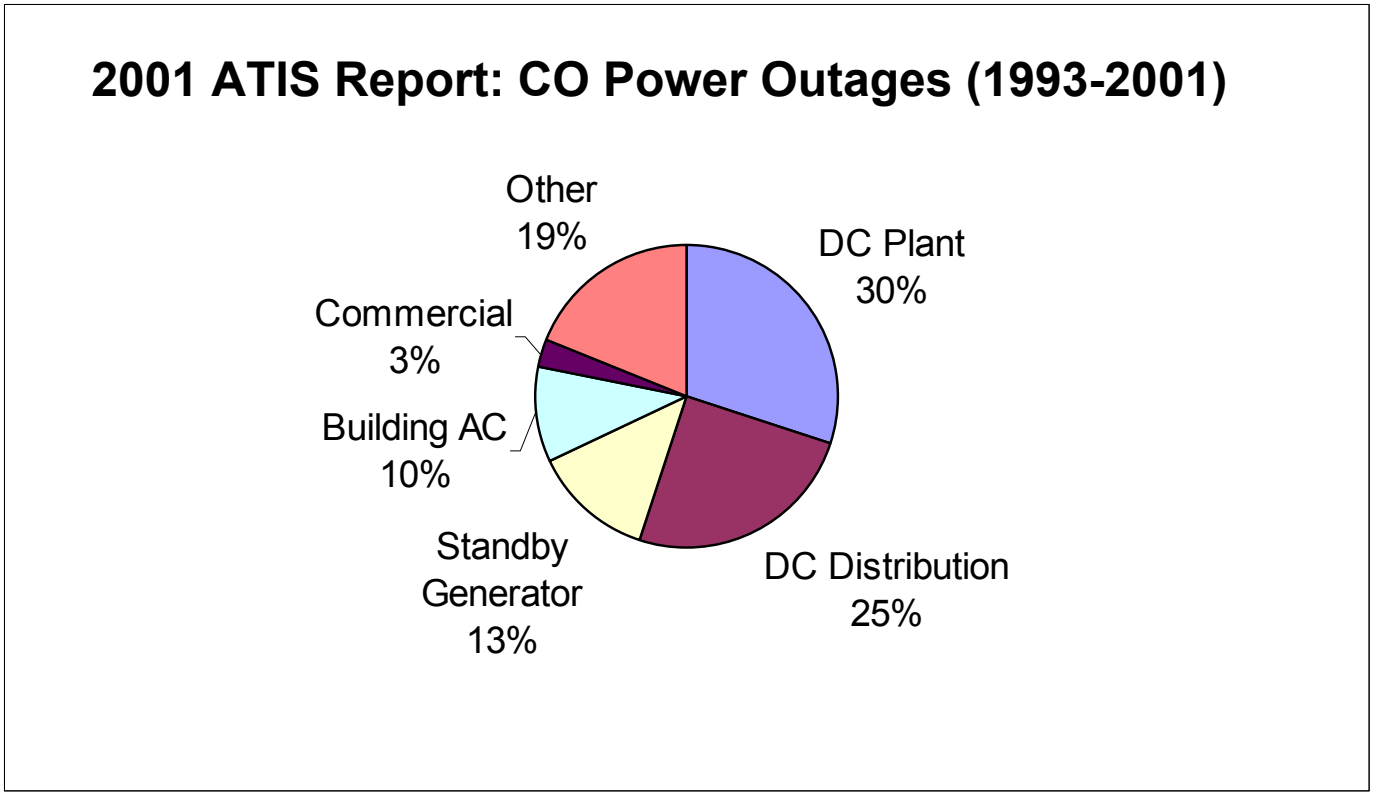
  - **Highlight the battery discharge (and other critical alarms) at remote centers so that it is virtually impossible to ignore. (NRIC V BPs: 5-689)**

- **For critical alarms produced by single contacts, use "normally closed" contacts that open for alarm. (NRIC V BPs: 5-692)**

- **Power monitors should be integrated into engineering and operational strategies. These monitors have proven to be particularly worthwhile during widespread power outages such as those produced by hurricanes and ice storms. (NRIC V BPs: 5-514, 5-517, 5-527, 5-602, 5-637, 5-650, 5-662)**

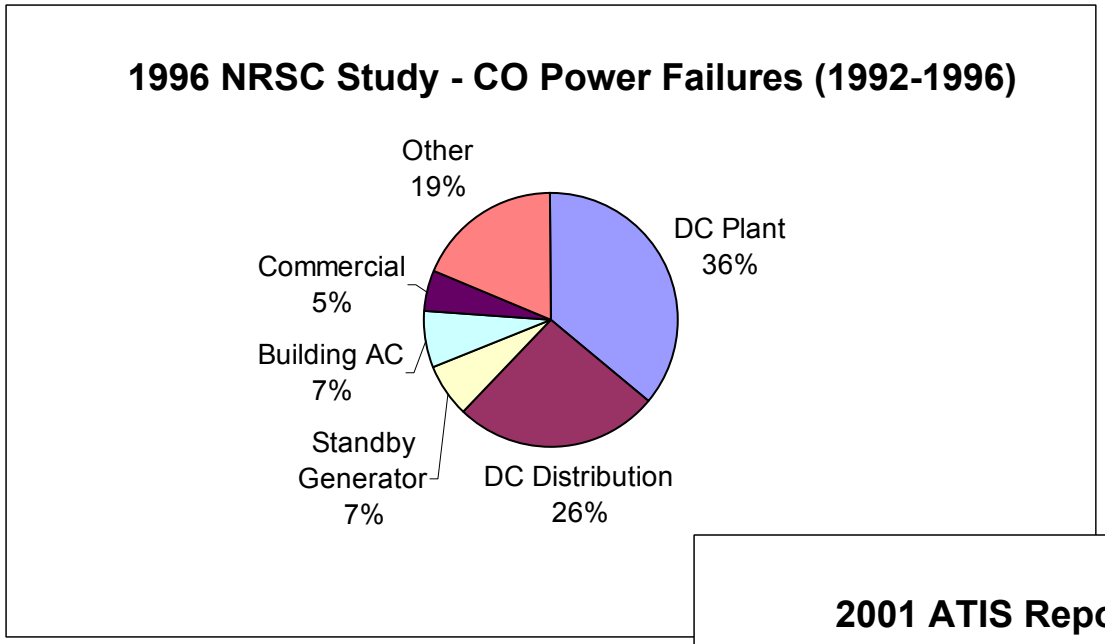
- **Maintain the power alarms: test the alarms on a scheduled basis; verify that the alarms are received and properly identified at remote locations; maintain alarm integrity during equipment removal. (NRIC V BPs: 5-612, 5-637, 5-650, 5-662)**

2001 ATIS Study – CO Power Failures

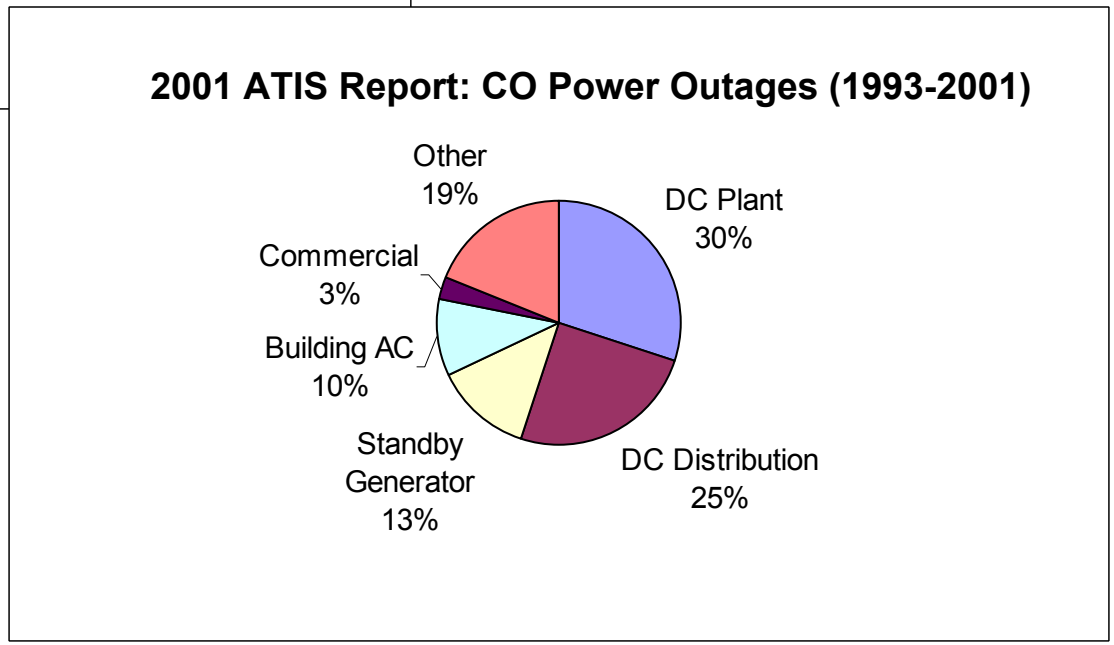


- **Outage frequency in Green region above baseline for 5th year in row**
- **Aggregated outage index in Green region above baseline for 4th year in row**

1996 NRSC STUDY: CO POWER FAILURES



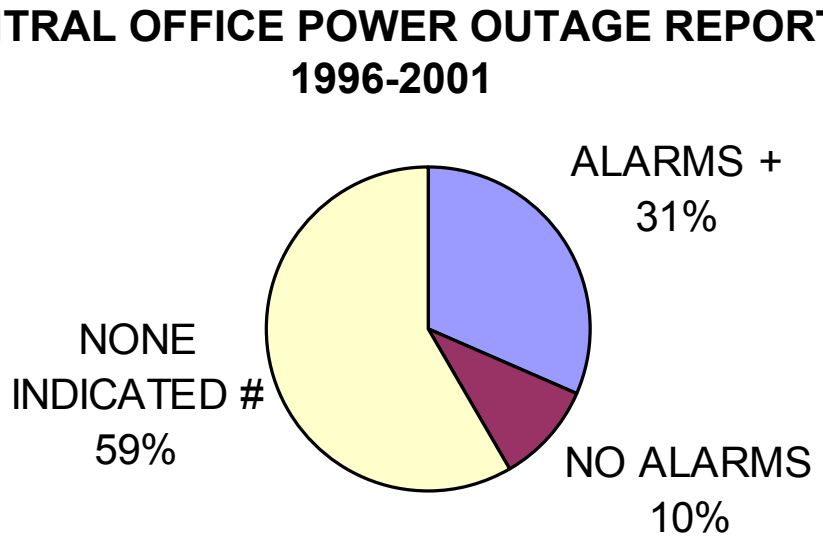
Studies have similar results



- **DC Plant Decreased**
  - **36% to 30%**
- **Standby Generator Increased**
  - **7% to 13%**

2001 ATIS Summary

- **1993-1995 FCC Outage Summaries – Not Available**
- **1996-2001 FCC Outages – 115 CO Power Outages were Reported**



+ ALARMS – 25% of Alarms were Insufficient or resulted in Insufficient Action

 # NONE INDICATED - Alarms may have been present but not stated on FCC Outage Report

NRIC VI – 14 Best Practices for Alarms

5-514	When available, Network Operators and Service Providers should utilize a management system capability (e.g., CORBA, SNMP) providing a single interface with access to alarms and monitoring information from all critical network elements.
5-517	Design packet network elements (and associated network management elements) with dynamic capacity management systems, including analysis tools and alarms, for managing peak load and overload conditions - bearer, signaling and network management traffic/messaging. The network elements should have the capability to handle overload conditions gracefully and shed traffic/messaging as necessary. Also, provisioning should consider the peak load conditions.
5-527	Equipment areas should be controlled and alarmed within manufacturers specifications (e.g., temperature, humidity).
5-602	Establish procedure to reactivate alarms after provisioning - The volume of alarms during provisioning create a potential for alarm saturation and makes it very difficult to differentiate between a real alarm and those caused by other activities. A common practice is to simply inhibit these alarms or set their thresholds so high they do not report. The danger here is that there must be a fail-safe measure to turn these alarms back on when the facility is carrying traffic.
5-612	A physical verification of both local and remote alarms and of remote network element maintenance access should be performed on all new equipment installed in the network before it is placed into service. When these functions are not performed, the probability of failure without notification is greatly increased. Likewise, if remote network element access is not verified, a simple restoration process may require technician dispatch to the site, resulting in further delay in service restoral.
5-637	Assure programs exist for alarm testing.
5-650	Place strong emphasis on human activities related to the operation of power systems (e.g., maintenance procedures, alarm system operation and response procedures, and training for operations personnel (craft)). Provide hands-on training for operation and maintenance of power equipment, including regularly scheduled refresher training. Train local workforces on AC switchgear to understand procedures and stage occasional rehearsals.
5-662	Service Providers should run engines for a period of at least 1 hour on a monthly basis and, at least 5 hours, with all available loads annually. Perform annual evaluation/maintenance of all power equipment. Maintain the power alarms by testing the alarms on a scheduled basis.
5-674	A modernization program should be initiated or continued to ensure that outdated power equipment is phased out of plant. Service Providers should consider and include the capabilities of smart controllers, local and remote monitoring, and alarm systems when updating their power equipment. Power monitors and smart controllers should be integrated into engineering and operational strategies.
5-688	Each company must have an alarm strategy.
5-689	Provide a separate "battery discharge" alarm for all battery plants. Program the alarm to repeat (e.g., at least every 15 minutes).
5-690	Redundancy must be provided, so that no single point alarm system failure will lead to a battery plant outage.
5-691	Highlight the battery discharge and other critical alarms at the remote center
5-692	For critical alarms produced by single contacts (one on one), use fail-safe, normally closed contacts that open for an alarm.

NRIC V – BEST PRACTICES for POWER

- **There are 65 BPs that are Power Related**

- **The BPs provide adequate coverage for Power**
  - **All of the Alarm categories from the 1996 NRSC Power Outage Study have BP coverage**
  - **NRIC V has identified 14 Alarm BPs**

NRIC V – POWER Related Best Practices

5-510	5-653	5-664	5-675	5-686	5-697
5-512	5-654	5-665	5-676	5-687	5-698
5-518	5-655	5-666	5-677	5-688	5-699
5-527	5-656	5-667	5-678	5-689	5-700
5-544	5-657	5-668	5-679	5-690	5-701
5-622	5-658	5-669	5-680	5-691	5-702
5-634	5-659	5-670	5-681	5-692	5-703
5-636	5-660	5-671	5-682	5-693	6-759
5-650	5-661	5-672	5-683	5-694	6-760
5-651	5-662	5-673	5-684	5-695	6-761
5-652	5-663	5-674	5-685	5-696	Total=65

NRIC V – Best Practices and Keyword Mapping

When selecting all Power BP (65), this chart shows the association with other key words to show the *other areas* that are affected by Power BPs

Policy	5
Industry Cooperation	1
Network Design	8
Network Provisioning	5
Network Operations	19
Network Interoperability	1
Technical Support	4
Network Elements	6
Essential Services	1
Security	4
Procedures	30
Facilities	5
Power	65
Fire	7
Emergency Preparedness	42
Disaster Recovery	32
Network Operator	65
Service Provider	64
Equipment Supplier	2

The existing NRIC V BPs are adequate

Recommendations – Power Outage Study Team

- **Recommendations to the NRSC Committee**
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    - » **Power Outages are increasing at annual rate of 12%**
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  - **Provide a WEB based "FCC Service Disruption Reporting (SDR) Form"**
    - » **Allows the greatest opportunity for consistent data collection**
- **Further Action**
  - **No further action for this Power Team.**
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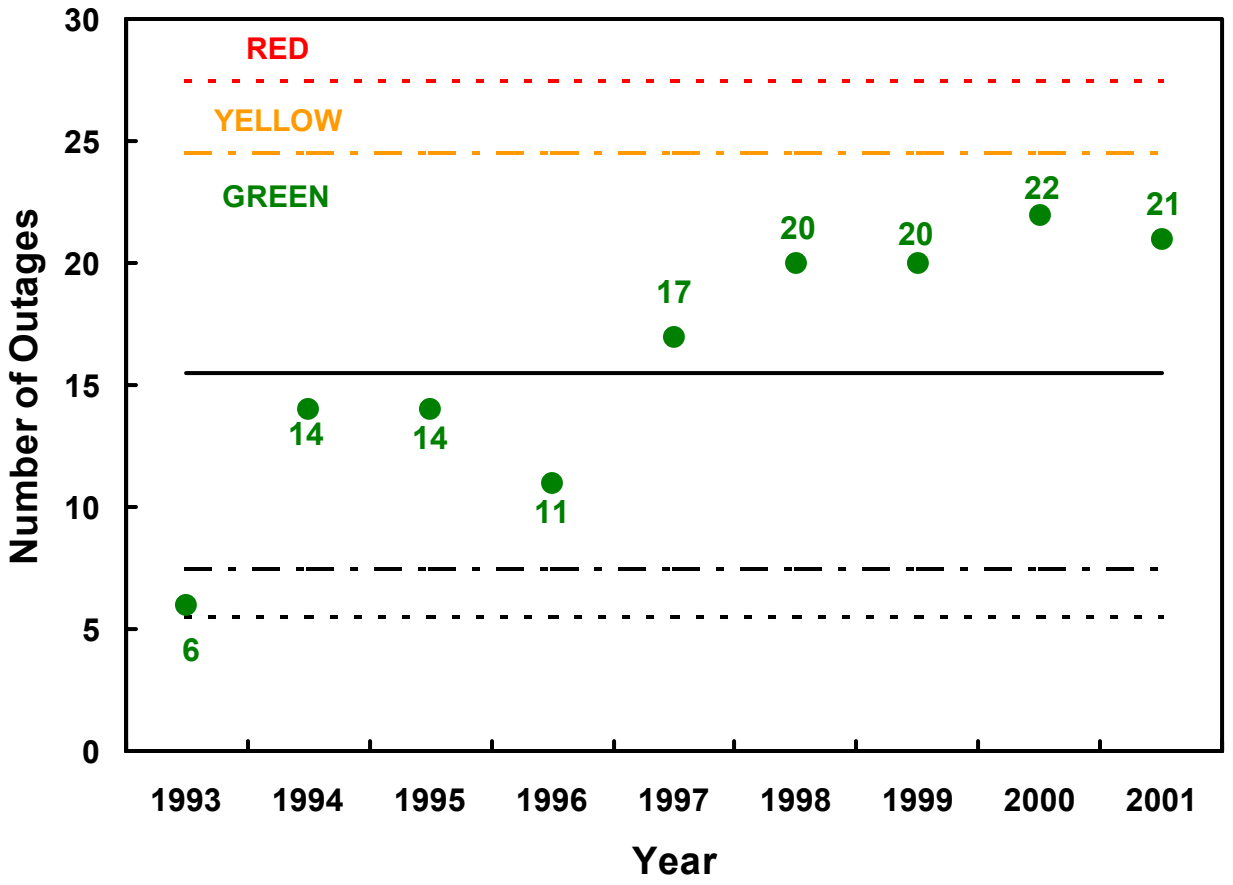
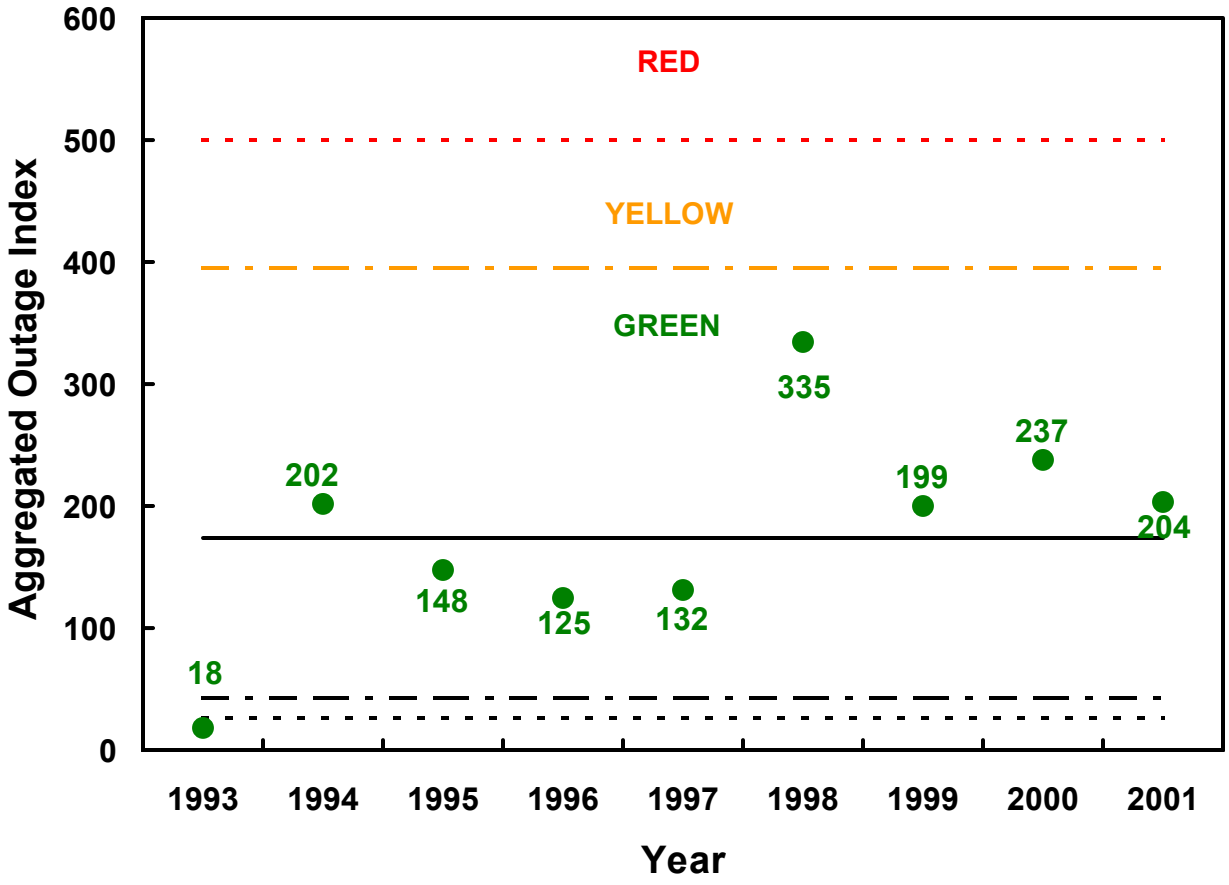
BACKUP VGs

CO Power Outage Frequency: Annual Control Chart



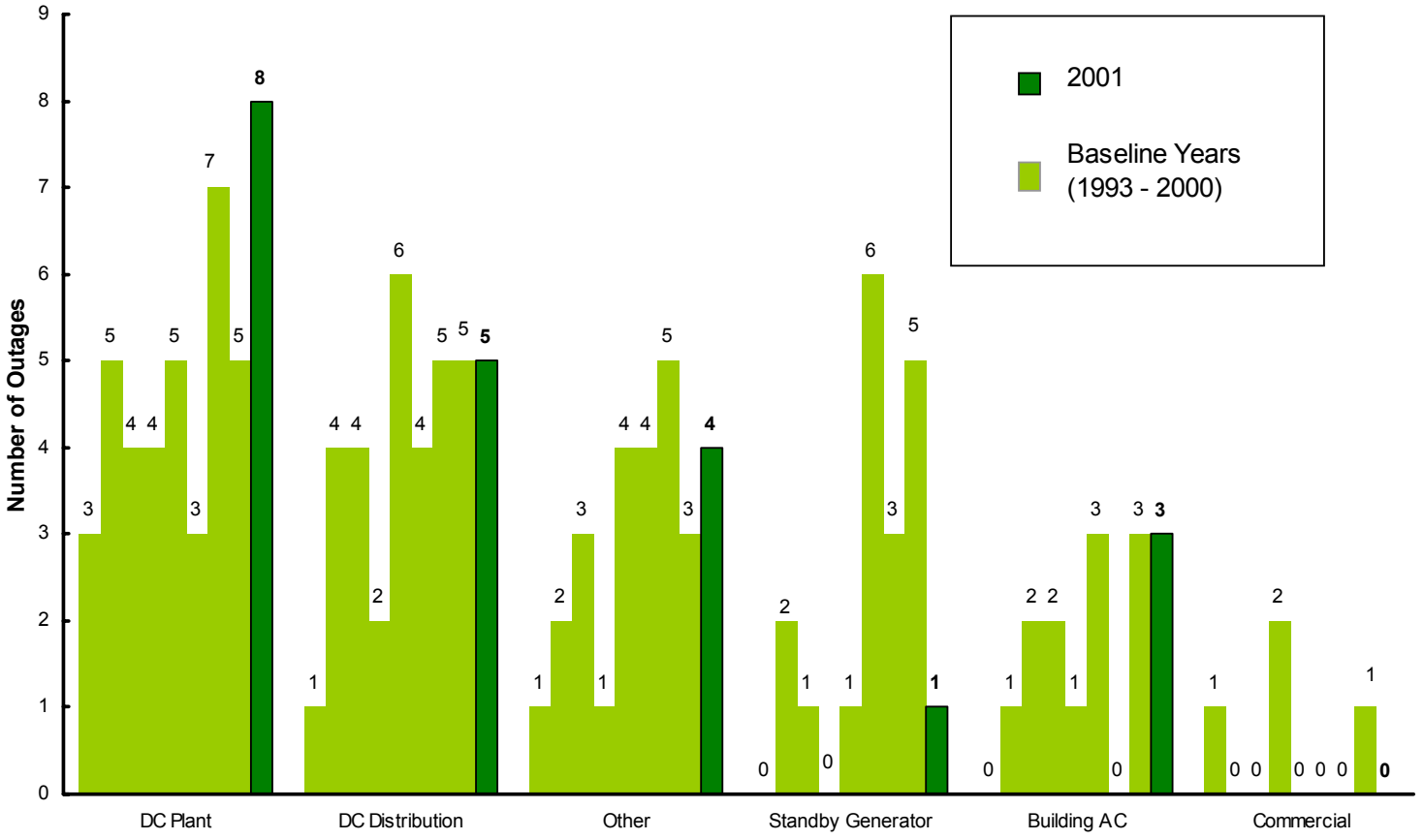
Source: "State of the U.S. Telecommunication Networks and Root Cause Analysis: 2001 Annual Report," ATIS Report, Jay Bennett, May 29, 2002.

CO Power Aggregated Outage Index: Annual Control Chart



Source: "State of the U.S. Telecommunication Networks and Root Cause Analysis: 2001 Annual Report," ATIS Report, Jay Bennett, May 29, 2002.

CO Power Failure Subcategories: Outage Frequency By Year



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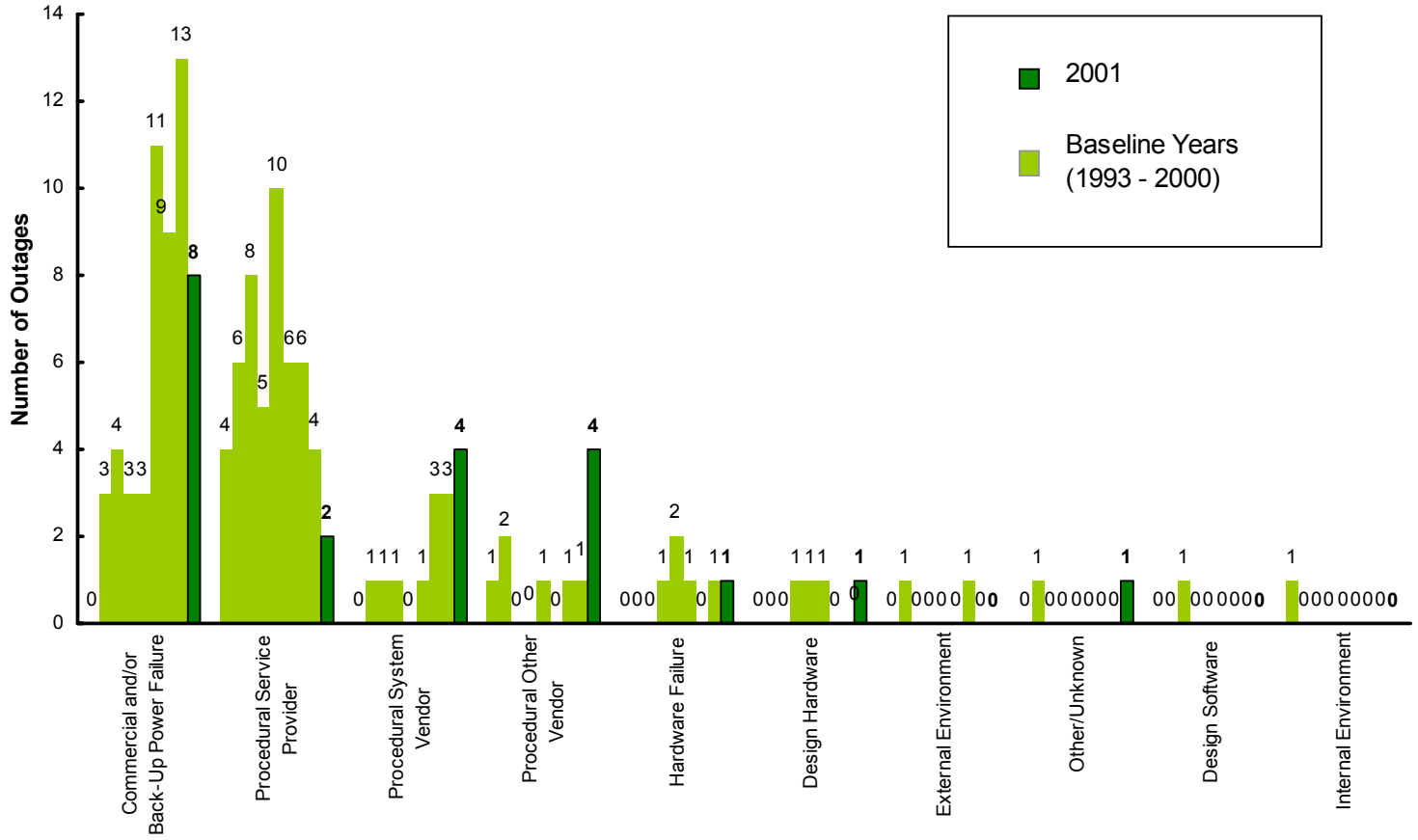
CO Power Root Cause Categories: Outage Frequency By Year



Source: "State of the U.S. Telecommunication Networks and Root Cause Analysis: 2001 Annual Report," ATIS Report, Jay Bennett, May 29, 2002.

NRIC VI – Power Related Best Practices

NRIC V BP No.	BEST PRACTICE
5-510	Critical Network Elements (e.g., Domain Name Servers, Signaling Servers) that are essential for network connectivity and subscriber service, need by design and practice to be managed as critical systems (e.g., secure, redundant, alternative routing).
5-512	Service Providers and Network Operators should perform periodic inspection of cable ways (e.g., through floor and through wall passage ways, sealing compounds, fire and water stopping, etc.).
5-518	Traffic monitoring and trending, forecasting, simulated failure analysis and emergency procedures should be designed and implemented in packet networks.
5-527	Equipment areas should be controlled and alarmed within manufacturers specifications (e.g., temperature, humidity).
5-544	To avoid water damage from floods, it is recommended that power equipment and other critical network elements should not be located in basements, if possible.
5-622	To reduce fires associated with DC power equipment, use ANSI T1.311-1998 “Standard for Telecommunications Environmental Protection, DC Power Systems” for key equipment locations (e.g., routers, central office switches, and other critical network elements)
5-634	Together with the Power Company and other tenants in the location, verify aerial power lines are not in conflict with hazards that could produce a loss of service during high winds or icy conditions.
5-635	In concert with other tenants in the location, ensure that AC surge protection is provided at the service entrance to minimize the effects caused by lightning or extreme voltage fluctuations.
5-636	Verify grounding arrangements.
5-650	Place strong emphasis on human activities related to the operation of power systems (e.g., maintenance procedures, alarm system operation and response procedures, and training for operations personnel (craft)). Provide hands-on training for operation and
5-651	Ensure diversity within power supply and distribution system so that single point failures are not catastrophic. For large battery plants in critical offices, provide dual AC feeds (odd/even power service cabinets for rectifiers). Transfer switches (UL st
5-652	Adhere to the following applicable power engineering design standards; TR-TSY-000513 (Power - LSSGR section 13), TR-NWT- 000063 (NEBS), TR-NWT-000295 (Isolated Ground Planes), TR-NWT-001089 (Electromagnetic Compatibility), and ANSI T1.311 (DC power System

NRIC VI – Power Related Best Practices

NRIC V BP No.	BEST PRACTICE
5-653	Service Providers should retain complete authority about when to transfer from the electric utility and operate standby generators.
5-654	Service Providers should not normally enter into power curtailment or load sharing contracts with electric utilities.
5-655	Service Providers and electric utilities should plan jointly to coordinate hurricane and other disaster restoration work.
5-656	Service Providers should establish a general requirement for some level of power conditioning, monitoring and protection for sensitive equipment.
5-657	Design standby generator systems for fully automatic operation and for ease of manual operation, when required.
5-658	Maintain adequate fuel on-site and have a well-defined re-supply plan. Improve fuel systems reliability by providing redundant pumps for day tanks and a manual-priming pump. Wherever possible, use dual-source generators with direct line natural gas as the
5-659	Provide maintenance systems for extended operation of emergency backup systems.
5-660	Have a well-defined plan that is periodically verified for providing portable generators to offices with and without stationary engines in the event of an engine failure.
5-661	Service Providers should routinely exercise engines with load, within permissible state and federal laws.
5-662	Service Providers should run engines for a period of at least 1 hour on a monthly basis and, at least 5 hours, with all available loads annually. Perform annual evaluation/maintenance of all power equipment. Maintain the power alarms by testing the alarm
5-663	Coordinate engine runs with all building occupants to avoid interruptions.
5-664	Provide indicating type control fuses on the front of the power panels, including smaller distribution panels.
5-665	Provide color-coded mimic buses showing power sources, transfer arrangements, essential/nonessential buses, etc.
5-666	Post at the equipment (or have readily available) single line and control schematics.
5-667	Keep circuit breaker racking/ratchet tools, spare fuses, fuse pullers, etc. on hand.
5-668	Clearly label the equipment served by each circuit breaker.
5-669	Develop and/or provide appropriate emergency procedures for AC transfer.
5-670	Provide surge arrestors (TR-NWT-001011 "Generic Requirements for Surge Protection Devices") at the AC service entrance of all Service Provider equipment buildings.

NRIC VI – Power Related Best Practices

NRIC V BP No.	BEST PRACTICE
5-671	Design and implement a professionally administered preventive maintenance and inspection program for electrical systems.
5-672	Provide a minimum of 3 hours battery reserve for central offices equipped with fully automatic standby systems.
5-673	When valve regulated batteries are used, provide temperature compensation on the rectifiers or some method to detect/prevent thermal runaway.
5-674	A modernization program should be initiated or continued to ensure that outdated power equipment is phased out of plant. Service Providers should consider and include the capabilities of smart controllers, local and remote monitoring, and alarm systems wh
5-675	For new installations, multiple smaller battery plants should be used in place of single very large plants serving multiple switches, etc.
5-676	Low voltage disconnects should not be used at the battery plant.
5-677	The rectifier sequence controller should be used only where necessary to limit load on the backup power generator.
5-678	Manufacturers are encouraged to continue to improve the human-machine interfaces of critical equipment (control, power, etc.).
5-679	Provide diverse power feeds for all redundant links (e.g., SS7, BITS clocks) and any components identified as “critical” single points of failure in transport and operations of the network (e.g., routers, cross-connects, switches).
5-680	Provide protective covers and warning signs on all vulnerable circuit breakers.
5-681	Ensure that the fuses and breakers meet quality level III reliability per Technical Reference (TR-TSY-000332), "Reliability Prediction Procedure for Electronic Equipment" (Telcordia).
5-682	Power wire, cable, and signaling cables that meet NEBS should be provided in all telecommunications locations.
5-683	Wherever possible, DC power cables, AC power cables and telecommunications cables should not be mixed.
5-684	Verify DC fusing levels throughout the power supply and distribution system, especially at the main primary distribution board, to avoid over fusing or under fusing. All new power equipment, including batteries should conform to NEBS.
5-685	Detailed methods and procedures are needed to identify all protection required around the energized DC bus.
5-686	Verify front and rear stenciling.

NRIC VI – Power Related Best Practices

NRIC V BP No.	BEST PRACTICE
5-687	Procedures and restoral processes are required for any cable-mining job. Develop and/or adopt a defined procedure for removal of unused cable (e.g., cable mining) and include the use of a clamp-on ammeter to identify hot circuits.
5-688	Each company must have an alarm strategy.
5-689	Provide a separate "battery discharge" alarm for all battery plants. Program the alarm to repeat (e.g., at least every 15 minutes).
5-690	Redundancy must be provided, so that no single point alarm system failure will lead to a battery plant outage.
5-691	Highlight the battery discharge and other critical alarms at the remote center.
5-692	For critical alarms produced by single contacts (one on one), use fail-safe, normally closed contacts that open for an alarm.
5-693	Emphasize use of Methods Of Procedures (MOPs); vendor monitoring; and performing work on in-service equipment or high-risk operations during low traffic periods.
5-694	On removal projects, check for current flow in power cables with AC/DC clamp-on ammeters before removing the associated fuses or opening the circuits.
5-695	Provide and test detailed action plans to address emergency situations, such as when both the commercial AC power and the standby engine fails to start. Continue to emphasize the need for local procedures and contingency plans for power emergencies.
5-696	Use infrared thermographic scanners to check power connections when trouble shooting, prior to installation acceptance, and every 5 years.

NRIC VI – Power Related Best Practices

NRIC V BP No.	BEST PRACTICE
5-697	Employ an "Ask Yourself" program to supplement conventional training. This initiative is intended to reinforce the responsibility every employee has to ensure flawless network service. Employees should stop and resolve problems when they can't answer yes to any of the following questions: 1). Do I know why I'm doing this work? 2). Have I identified and notified everybody who will be directly affected by this work? 3). Can I prevent or control a service interruption? 4). Is this the right time to do this work? 5). Am I trained and qualified to do this work? 6). Are work orders, MOPs, and supporting documentation current and error-free? 7). Do I have everything I need to quickly restore service if something goes wrong? 8). Have I walked through the procedure?
5-698	In preparation for a hurricane, place standby generators on line and verify proper operation of all subsystems.
5-699	Where appropriate, design standby systems to withstand high winds, wind-driven rain and debris.
5-700	Consider the need for power expertise/power teams.
5-701	Provide security from theft of portable generators. Trailer mounted generators equipped with wheel locks are recommended.
5-702	Minimize dependence on equipment requiring AC power feeds in favor of DC-powered components.
5-703	Remote power maintenance systems should be secured to prevent, detect and contain any unauthorized access, modification or use.
6-759	Network Operators and Service Providers should ensure that engineering, design, and installation processes address how new network elements are integrated into the office synchronization plan.
6-760	Network Operators and Service Providers should develop management/records keeping tools that accurately track the diversity of internal wiring for office synchronization, including timing leads and power.
6-761	Network Operators and Service Providers should conduct periodic verification of the office synchronization plan and the diversity of timing links, power feeds and alarms.