



DEPARTMENT OF INFORMATION TECHNOLOGY
Communications Engineering

Tucson Regional Communications and Networking Standards

**City of Tucson Proprietary
Requirements for New and Existing City Facilities**

Local and Wide Area Networks
Radio Communications
Rio Nuevo Planning and Execution

April 2007

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Details

- FO 100 – Conduit Installation
- FO 300 – Fiber Optic Pullbox
- FO 301 – Fiber Optic Vault

Purpose

In order to meet the City of Tucson's (City's) current and future communications requirements, a comprehensive Wide Area Network (WAN) is being developed. This network will provide connection to all existing and new city buildings of significance. All city buildings or campus communication infrastructures (intrabuilding and interbuilding data, voice, and video services), known as Local Area Networks (LAN) will be connected to the WAN.

To facilitate the implementation of this system in an economic and community responsive manner, portions of the system will be constructed in association with other public improvement projects being undertaken by various City Departments. This practice can provide a reduction in the initial capital costs of the system. Specifically, by integrating the installation of the communications system with other projects, the adverse impact of this installation will be mitigated by reducing the number of construction projects occurring within the City's Right-of-Way.

Such developments as Rio Nuevo are in need of clearly defined communications requirements. Implementation will be initiated during the planning stage, carried through all phases of conceptual development, and sustained through execution.

The City is also involved in efforts to explore the advantages of regional partnering with other governmental and educational entities. Within this context, such entities are encouraged to make use of the guidelines herein, to the end of a consistent regional application.

This document is intended to set forth the basic criteria for the WAN and LAN, and to address the pertinent aspects of its design, construction, and testing. Specific requirements have been established for City Architecture & Engineering projects on City real property, for City Engineering projects in City Right-of-Way, for developments such as Rio Nuevo, and for in-building radio coverage. Requirements have also been identified for non-City entities working in City Right-of-Way in the sections entitled "Project Managerial Requirements for Private Projects in City Right-of-Way" and "Project Execution Requirements for Private Projects in City Right-of Way."

This is a document which is anticipated to be updated annually. If any portion of this document has conflicts or errors, is subject to misinterpretation, or is not workable or constructable, please bring it to the attention of the City of Tucson Communications Engineering (CE) Division.

Definitions

Building Industry Consulting Service International (BICSI): An organization of telecommunications professionals dedicated to the development of technical manuals and standards, training, and registration manuals.

Local Area Network (LAN): A geographically limited data communications system for a specific user group consisting of a group of interconnected group of computers sharing applications, data, and peripheral devices such as printers and CD-ROM drives intended for the local transport of data, video, and voice. Such a system can serve either a single building or a campus environment.

Registered Communications Distribution Designer (RCDD): The title awarded to BICSI members who demonstrate expertise in the design, integration, and implementation of telecommunications (voice, data, video, audio, and other low-voltage control) transport systems and their related infrastructure components. This designation has become a de facto certification for professional competence within the telecommunications industry.

Communications Engineering (CE): A Division of the City of Tucson Department of Information Technology which has been assigned as one of its principal missions the oversight, planning, coordination and execution of a comprehensive City-wide communications master plan.

Wide Area Network (WAN): An internetwork that uses telecommunications links to connect geographically distant LANs. Tucson's WAN is comprised of City fiber run in its Right-of-Way.

City Architecture & Engineering Division Project Managerial Requirements

Design shall conform to sections 17000 and 975, Telecommunications Infrastructure. Project Managers shall instruct their consultant designers to insure that any written specifications are formatted as applicable to each project such that there is no room for misinterpretation on the part of any contractor or field inspector. Although Project Managers and their Consultants may import the content of these requirements and guidelines into their project designs, said requirements and guidelines are not substitutions for due diligence in design, procurement, and construction. **Details and specifications shall reflect actual project conditions.**

The sections below entitled “City Architecture and Engineering Division Project Execution Requirements”, “City Architecture and Engineering Division General On-Site Design Requirements”, and “800 Mhz In-Building Amplification System Requirements” have been broken out for the convenience of all Project Managers. However, it is the Architecture & Engineering Division Project Manager’s responsibility to verify that any work delegated to outside consultants is performed in compliance with these City of Tucson (City) Guidelines.

Project Managers shall coordinate with Communications Engineering (CE) to determine the optimum connection point and routing to the WAN. Final cost estimation for said connections shall be detailed as a part of the subject project. For the purposes of site selection, it may be helpful to access the web site <http://dot.ci.tucson.az.us/mapcenter/>, select “TDOT Maps”, and view “Fiber Optic”.

It is the responsibility of the Project Manager to determine whether any pathway, conduit system, horizontal or riser cable, copper or optical fiber, will be installed in plenum spaces. If so, the above shall be plenum rated.

Project Construction Administrators shall coordinate with CE during the construction period. This coordination shall include a discussion of all system modifications, and the schedule of inspections and system testing. All tests shall be witnessed by a CE representative. Final acceptance of the project shall not be issued until such time that CE or its representative approves and accepts the City fiber conduit system. The representative of CE observing the testing of the conduits may install a tag labeled “DEDICATED CITY OF TUCSON COMMUNICATION CONDUIT. CONTACT TECHNICAL PLANNING AND RESOURCES DIVISION BEFORE USING.” when the conduit run has satisfactorily passed all testing. No party other than CE shall remove said plug and label once it is installed.

CE shall be included in the review process for all Architecture/Engineering Division projects. It shall be the ultimate responsibility of the Project Manager to insure that all CE comments are conveyed to any designer, and are properly addressed.

Upon approval of City of Tucson Developmental Services, one complete set of drawings shall be forwarded to CE. One complete set of drawings shall be forwarded to Communications Maintenance.

Project Managers shall provide customers and end users with the information detailed in the section entitled “For City Architecture and Engineering Division End Users and Customers”.

Upon project completion, the Project Manager shall verify that the Contractor has supplied new blueprints and electrically formatted drawings, which reflect all changes and “asbuilt” information.

City Architecture & Engineering Division Project Execution Requirements

All Local Area network (LAN) and Wide Area Network (WAN) projects shall be designed by a Registered Communications Distribution Designer (RCDD) with a current Building Industry Consulting Service International (BICSI) registration number stamp.

Communications/Data drawings shall be identified by T series numbers in the approved Construction Drawings.

The Communications/Data section of specifications manual shall be numbered separately and distinctly from other sections. Format shall follow the section entitled “SECTION 17000 – TELECOMMUNICATIONS INFRASTRUCTURE”. “DETAILS” also have been incorporated into City of Tucson (City) requirements for Architecture and Engineering projects.

As part of each submittal, Communications Engineering (CE) shall be furnished with a tabulation of the following system information.

- (A) The station and offset of each pull box and vault.
- (B) The total length of each conduit run between pulling points.
- (C) The total degree of bends of all vertical and horizontal bends between pulling points.
- (D) The latitude and longitude of the centerline of the pull boxes and vaults.
- (E) Specific stub-out locations proposed for each pullbox and vault.

Plans depicting installations interior to buildings shall be prepared using the drafting standards of the department responsible for the project. Plans depicting installations exterior to buildings shall be drafted in accordance with Pima County/City of Tucson Standard Detail Numbers 100 and 101. The conduit shall be clearly indicated with respect to its horizontal and vertical alignment. The locations of all pull boxes and vaults shall be indicated by its station and offset. The identification number of each pull box and vault shall be included on the plans.

Any pathway, conduit system, horizontal or riser cable, copper or optical fiber installed in plenum spaces shall be plenum rated.

All drawings shall include the following general notes:

WIDE AREA NETWORK (WAN) CONDUIT SYSTEM GENERAL NOTES:

1. All existing City fiber facilities shall be protected in-place unless specifically noted otherwise on the construction documents. No existing City fiber optic conduit system or cable shall be altered in any way without the written approval of the City Communications Engineering Division.

2. All new City fiber conduit systems shall be cleaned and mandrel tested by the contractor in the presence of a Communications Engineering (CE) representative. Provide 72 hour advance notice to Bobby Sweet at 419-3459.
3. Conduit ends shall be capped when work is not in progress. RGS sweeps terminating in pull boxes shall be plugged.
4. It shall be the sole responsibility of the Contractor to repair all existing City conduit systems and appurtenances damaged by construction. Immediate notification of any damaged existing conduit system, whether occupied or unoccupied, shall be reported to the Construction Administrator and the Communication Maintenance Division, at 791-4634 Monday through Friday between 7:30am to 4:30pm or 791-4830 after hours and weekends.
5. For repairs of occupied City fiber conduit systems, the Contractor shall repair, clean and mandrel test the conduit systems in the presence of a Communication Maintenance representative. The contractor shall install, re-terminate, and test new approved optical fiber cable as directed by the Communication Maintenance representative. The Contractor shall present such representatives with test results, in booklet form and ASCII format, with one licensed version of the original test equipment software, which will allow the City to view the test results as the software was designed. Acceptance of the work shall not occur before all documentation, test results, certification of test results and operation by such representatives has been approved.
6. For repairs of unoccupied City fiber conduit systems, the Contractor shall repair, clean and mandrel test the conduit systems in the presence of a Communication Maintenance representative.
7. All pull boxes/vaults shall be provided with a 5/8" by eight foot ground rod and acorn, driven vertically in the corner with six inches of rod exposed above the top of the drainage rock.
8. The absolute maximum length between pull boxes or vaults shall not exceed 600 feet.
9. Communications conduit between pull boxes/vaults shall have a maximum deflection of 270 degrees.
10. Communications conduit shall be buried a minimum of 36" to the top of the conduit below finish grade.
11. Communications conduit shall be 4" schedule 40 PVC.
12. All bends 45 degrees and larger shall be rigid galvanized steel sweeps 12 times the conduit diameter or 48" radius, double wrapped with 10 mil PVC tape.

13. All conduits not occupied by innerduct and tracer wire shall have an unspliced unknotted 2500 pound test 22AWG detectible mule tape installed and secured with 4' slack at each pullbox.
14. All conduit shall be capped and covered with aggregate bedding material, or encased after each day's work to prevent shrinkage and other displacement of the conduit.
15. All materials and appurtenances called out on the plans or required for a complete system shall be new. No used or refurbished items or materials shall be allowed.
16. If there is any conflict among the plans, special provisions, and/or the standard details or specifications of the City of Tucson, or any conflicts within the documents cited above, the higher standard shall apply.
17. Upon project completion, the Contractor shall supply new blueprints and electrically formatted drawings, which reflect all changes and "asbuilt" information

For City Architecture & Engineering Division End Users and Customers

LOCAL AREA NETWORK (LAN) STATION CABLE

Definition:

The workstation cable refers to the category five extended data cable that connects the user's equipment to the in-building data wiring system.

Standard:

- (1) Workstation cable shall not exceed 15 feet from modular plug to modular plug.
- (2) Workstation cable shall be purchased pre-assembled with a category five extended certification.

Exception:

Contact Communications at 791-3121 for special situations that require greater than 15-foot cables.

COMPUTER WORKSTATION/PERIPHERALS AC POWER SURGE PROTECTION

Definition:

A portable multi-outlet passive protection device used to remove, filter or clamp harmful or disruptive AC power deviations.

Standard:

The surge protector shall be a Tripp Light, Model ISOBAR x or approved equal.

Exceptions:

Contact Communications at 791-3121 for special surge protection requirements.

LOCAL AREA NETWORK (LAN) INFORMATION OUTLET

Definition:

A quadraplex wall mounted data connection device that provides three in-building data jacks and one in-building telephone jack.

City Architecture & Engineering Division General On-Site Design Requirements

Design. The design of the conduit system shall adhere to TIA/EIA 569B standards, TIA/EIA758A standards, and shall accommodate the cabling requirements of TIA/EIA 568-B.1, 568-B.2, and 568-B.3 standards.

General Alignment. Where installed along side of other utilities, conduit alignment shall follow the general horizontal alignment of such underground utilities to the fullest extent possible. Utilize joint trenching as much as practicable to reduce the cost associated with trench work. When the alignment of the trenching for the other utilities does not allow for the installation of the City fiber conduit, the conduit shall be installed in a separate trench.

Distance Between Pull Boxes or Vaults. The absolute maximum length of the conduit between pull boxes or vaults shall not exceed 600 feet.

Vertical and Horizontal Alignment. The horizontal and vertical alignment of the conduit system shall be the straightest alignment feasible. The design shall minimize horizontal and vertical drift in the conduit runs. Transitions and bends shall be made using the longest radius possible.

Maximum Bends Between Pulling Points. The sum of all horizontal and vertical bends shall not exceed 270 degrees in any conduit run. Bends with a radius of 500 feet, or greater, may be excluded from this criterion.

Innerduct And Tracer Wire. All 4 inch conduits, except those referred to below as dedicated to Telephone and CATV, shall have 4 (quantity) 1 inch *smoothwall exterior ribbed interior* innerducts with a continuous 1250 pound test mule tape installed in each innerduct, along with 1 (quantity) 10 AWG green continuous nonspliced copper tracer wire installed in the 4 inch conduit.

Watertight Alibi. Watertight Alibi shall consist of a Quadraplex Duct Plug designed to seal around, organize, and support innerduct where it emerges at the top of all risers, pull boxes, and vaults. Fasteners shall be stainless steel. Plug shall support a minimum of 400 lbs of cable, and shall be removable. Jackmoon or equivalent. No chemical seals will be accepted

Blank Duct Plugs. Blank Duct Plugs shall be installed in each individual innerduct where it emerges at the top of all risers, pull boxes, and vaults. Shall be all plastic construction, corrosion proof, water and air tight to 30 psi. Jackmoon or equivalent.

Standard Conduit Requirements. Unless otherwise approved, all Wide Area Network (WAN) conduit shall be 4 inch, schedule 40 PVC conduit buried a minimum of 36" to the top of the conduit below finished grade. In special cases, such as in association with borings, rolled pipe (HDPE) may be utilized when approved by the City of Tucson Construction Representative and the CE Representative. The number and size of the HDPE will be selected based on the specifics of the location. Pull boxes shall be installed at the termini of each conduit run. In addition to the (2) 4" schedule 40 PVC conduits for the WAN referenced above, (1) 4" schedule 40 PVC conduit shall be installed for cable television (CATV) facilities, and (1) 4" schedule 40 PVC conduit shall be installed to the Entrance Facility (EF) for Telephone, or the current Long Distance Carrier. Coordinate with the Authority Having Jurisdiction (AHJ) for Telephone and CATV conduit routing, terminations, and project-specific requirements.

Concrete Encasement. All conduits installed under roadways and parking lots on City property shall be encased in Class B (2500psi) concrete a minimum of 3" on all sides. All other conduit runs on City property and City Right of Way shall be given serious consideration as candidates for encasement in concrete. Coordinate with CE, who will balance such considerations as the critical nature of the facility, existence of alternate paths, backup communications paths, and the costs involved. Details and specifications shall reflect actual project conditions.

Peripheral Communications Equipment. Any peripheral equipment associated with cable TV (video), phone service (voice), or data (Internet) shall be installed in as unobtrusive, discreet, and disguised manner as is practicable given all design constraints. If at all possible, such devices shall be buried. Where this is not possible, every effort must be made to install communication devices either:

- Hidden from public view, or
- Disguised as a natural part of the environment (such as a rock or boulder, natural vegetation, etc.) or building.

Hidden or disguised equipment must not interfere with pedestrian flow.

Energy Management Control System (EMCS). All new COT facilities shall be provided with an Information Outlet in the physical plant or mechanical room. Any mechanical system not physically located in the physical plant or mechanical room shall have an alarm circuit that is connected to the EMCS. Coordinate EMCS design requirements with COT Energy Manager from General Services Department.

City Department of Transportation Project Managerial Requirements

Design shall conform to sections 17000 and 975, Telecommunications Infrastructure. Project Managers shall instruct their consultant designers to verify that any written specifications be formatted as applicable to each project such that there is no room for misinterpretation on the part of any contractor or field inspector. Although Project Managers and their Consultants may import the content of these requirements and standards into their project designs, said requirements and standards are no substitution for due diligence in design, procurement, and construction. **Details and specifications shall reflect actual project conditions.**

The section entitled “City Department of Transportation Project Execution Requirements” has been broken out for the convenience of all Project Managers. However, it is the Department of Transportation (DOT) Project Manager’s responsibility to verify that any work delegated to outside consultants is performed in compliance with these City of Tucson Standards.

Project Managers shall coordinate with Communications Engineering (CE) to determine the optimum routing of the City fiber conduit. Final cost estimation for said connections shall be detailed as a part of the subject project.

CE shall be included in the review process for all DOT projects. It shall be the ultimate responsibility of the Project Manager to insure that all CE comments are conveyed to any designer, and are properly addressed.

Project Construction Administrators shall coordinate with CE during the construction period. This coordination shall include a discussion of all system modifications, and the schedule of inspections and system testing. All tests shall be witnessed by a CE representative. Final acceptance of the project shall not be issued until such time that CE or its representative approves and accepts the City fiber conduit system. The representative of CE observing the testing of the conduits may install a tag labeled “DEDICATED CITY OF TUCSON COMMUNICATION CONDUIT. CONTACT TECHNICAL PLANNING AND RESOURCES DIVISION BEFORE USING.” when the conduit run has satisfactorily passed all testing. No party other than CE shall remove said plug and label once it is installed.

Upon project completion, the Project Inspector shall verify that the Contractor has supplied CE with asbuilt drawings on reproducible velum paper.

City Department of Transportation Project Execution Requirements

For applications where conduit for the fiber optic infrastructure is to be installed under funding specific to the subject project, the only items to be installed shall be the 4" conduit itself, a 2500 # rated pull strength traceable mule tape, conduit end caps, and #7 Pull boxes w/Extension at 600 foot maximum intervals and at project termini. Pullbox shall have bolted lids stating "COMMUNICATIONS". If open trenching is employed, metallic fiber optic warning tape shall be installed. A ground rod, supplied by the Communications Engineering Division, shall be installed at each pullbox.

Mandrel testing of this conduit system shall be witnessed by a Communications Engineering (CE) representative before final acceptance. If the mandrel test fails, the Contractor shall repair or replace the conduit system and re-test at no cost to the City of Tucson. After a successful mandrel test, a 2500-lb. continuous traceable mule tape shall be installed in each conduit run, leaving a 5 foot coil in each pullbox and tied off. Each conduit run shall then be capped at both ends and secured to prevent debris from entering the system.

Until further notice, any requirements and guidelines below which exceed this de minimus concept shall be applied in circumstances only where adequate funding sources have been identified for such.

The communications/data section of specifications manual shall be numbered separately and distinctly from other sections. Format shall follow the section entitled "Section 975 – Telecommunications Infrastructure: DOT Format". "Details" have also been incorporated into City of Tucson (City) requirements for City Department of Transportation projects.

As part of each submittal, Communications Engineering (CE) shall be furnished with a tabulation of the following system information.

- (A) The station and offset of each pull box and vault.
- (B) The total length of each conduit run between pulling points.
- (E) The total degree of bends of all vertical and horizontal bends between pulling points.
- (F) The latitude and longitude of the centerline of the pull boxes and vaults.
- (E) Specific stub-out locations proposed for each pullbox and vault.

The design of the conduit system shall adhere to TIA/EIA 569B standards, TIA/EIA 758A standards, and shall accommodate the cabling requirements of TIA/EIA 568-B.1, 568-B.2, and 568-B.3 standards. Design and construction shall also comply as applicable to the Pima County/City of Tucson Standard Specifications and Details for Public Improvements and to the Tucson Water Standard Specifications.

The plans shall be prepared using the drafting standards of the Department responsible for the project. Plans depicting installations exterior to buildings shall be drafted in accordance with

Pima County/City of Tucson Standard Detail Numbers 100 and 101. The conduit shall be clearly indicated with respect to its horizontal and vertical alignment.

The alignment of the conduit shall follow the general horizontal alignment of new water lines, street lighting and traffic signal conduits, or other underground utilities to the fullest extent possible. The utilization of a joint trench shall be employed as much as practicable. When street lighting or traffic signal conduit is encased in concrete, the fiber optic conduit shall be encased in concrete also. When the alignment of the trenching for the other utilities does not allow for the installation of the City fiber conduit, the conduit shall be installed in a separate trench.

The absolute maximum length of the conduit between pull boxes or vaults shall not exceed 600 feet.

When installed adjacent to water mains, the conduit shall be encased in Controlled Low Strength Material (CLSM). The conduit shall be supported on plastic spacers capable of preventing displacement of the conduit during the placement of the CLSM. During the placement of the encasement material, the conduits shall be tied down to prevent the conduit from floating. The minimum cover on all sides of the conduit shall be 3 inches.

In all areas where the depth of cover above the conduit is less than 30", the conduit shall be encased in concrete. The concrete encasement shall be a minimum of Class B (2,500 PSI) in accordance with Pima County/City of Tucson Standard Specifications and provide a minimum cover on all sides of the conduit of 3 inches.

When the conduit is installed in a joint trench with a water main, the bedding and shading material shall be aggregate bedding material meeting the specifications for the water main. The conduit shall be installed at an invert equal to, or above, that of the water line and offset from the water line as indicated on the Standard Details (Appendix B). The selection of the location of the conduit shall be approved by Tucson Water. The conduit(s) shall generally be installed at a uniform depth of cover. However, when the vertical alignment of the water main offers a smoother profile for the conduit, the conduit(s) may follow the general alignment of the water main. At crossings of other utilities, where the water main is rolled under another utility line, effort(s) shall be made to maintain the vertical alignment of the conduit. In cases where it is impossible to maintain the alignment of the conduit at the utility crossing, the grade of the conduit shall be transitioned using the minimum number and the longest radius bends. To accomplish this, the water system design shall consider the use of 11-1/4 degree bends, or 22-1/2 degree bends for the water line.

The horizontal and vertical alignment of the conduit system shall be the straightest alignment feasible. The design shall minimize horizontal and vertical drift in the conduit runs. Transitions and bends shall be made using the longest radius possible. Bends shall not be installed unless absolutely necessary. The sum of all horizontal and vertical bends shall not exceed 270 degrees in any conduit run. Bends with a radius of 500 feet, or greater, may be excluded from this criterion.

Unless otherwise approved, all conduit shall be 4 inch, schedule 40 PVC conduit. In special cases, such as in association with borings, rolled pipe (HDPE) may be utilized when approved by the City Construction Representative and the CE Representative. The number and size of the HDPE will be selected based on the specifics of the location.

Conduit with integral innerduct shall be accepted as an alternate to the 4" PVC, with rigid steel bends and their related innerduct installed separately. Such conduit shall meet the requirements of Section 975.

Pull boxes shall be installed at the termini of each project, at locations within the conduit system as required to meet the recommended maximum conduit length and the maximum degree of bends, and at locations required to facilitate the connection to existing and future conduit runs. Pull boxes shall be constructed and installed according to the Pima County/City of Tucson Specifications and Details for Public Improvements, Number Seven Pullbox with Extension. The boxes shall be furnished with a lockable, or bolted, cover labeled "communications".

In the selection of pull box locations, consideration shall be given to potential location of future City fiber optic conduit runs intersecting the project. At all locations where existing, or future, conduit runs cross the project, a pull box shall be located near the point of intersection. At all locations where new conduit crosses an existing City fiber conduit, a pathway shall be provided between the conduit runs. At locations of future conduit runs, a conduit stub-out shall be installed along the future alignment, to a location which is outside of the limits of any future pavement. Pull boxes shall be located in the vicinity of City facilities scheduled to be connected to the City fiber system. When pull boxes are located near a signalized intersection, the pull box shall be located as near as practicable to the Control Cabinet, and connected to it.

For Rio Nuevo Roadway work, all peripheral equipment associated with cable TV (video), phone service (voice), or data (Internet) shall be installed in an unobtrusive, discreet, and disguised manner. If at all possible, such devices shall be buried. Where this is not possible, communication devices must then be either hidden from public view, or disguised as a natural part of the environment (such as a rock or boulder, natural vegetation, etc.) or building. Hidden or disguised equipment must not interfere with pedestrian flow or block scenic views, disturbing the aesthetics of the area. Equipment areas should not be fenced unless such fencing is installed to meet Code requirements or standard design practice as applicable to life safety issues; in such cases this fencing shall meet the intent of this paragraph in its aesthetic presentation. The equipment must not emit detectable noises or sounds unless they are placed far enough from pedestrian traffic flow that the noise is undetectable. The telephone number for Graffiti Abatement shall be discreetly posted toward the bottom of the equipment. It shall be the responsibility of any vendor or provider to periodically check equipment to ensure that it complies with these standards. Noncompliant vendors may be fined or directed to relocate or remove equipment. Obsolete or unused facilities which have not served a customer for 90 days shall be removed in a timely manner. Cost of removal shall be the responsibility of the vendor or provider.

All drawings shall include the following general notes:

WIDE AREA NETWORK (WAN) CONDUIT SYSTEM GENERAL NOTES:

1. All existing City fiber facilities shall be protected in-place unless specifically noted otherwise on the construction documents. No existing City fiber optic conduit system or cable shall be altered in any way without the written approval of the City Communications Engineering Division.
2. All new City fiber conduit systems shall be cleaned and mandrel tested by the contractor in the presence of a Communications Engineering (CE) representative. Provide 72 hour advance notice to Bobby Sweet at 419-3459.
3. Conduit ends shall be capped when work is not in progress. RGS sweeps terminating in pull boxes shall be plugged.
4. It shall be the sole responsibility of the Contractor to repair all existing City conduit systems and appurtenances damaged by construction. Immediate notification of any damaged existing conduit system, whether occupied or unoccupied, shall be reported to the Construction Administrator and the Communication Maintenance Division, at 791-4634 Monday through Friday between 7:30am to 4:30pm or 791-4830 after hours and weekends.
5. For repairs of occupied City fiber conduit systems, the Contractor shall repair, clean and mandrel test the conduit systems in the presence of a Communication Maintenance representative. The contractor shall install, re-terminate, and test new approved optical fiber cable as directed by the Communication Maintenance representative. The Contractor shall present such representatives with test results, in booklet form and ASCII format, with one licensed version of the original test equipment software, which will allow the City to view the test results as the software was designed. Acceptance of the work shall not occur before all documentation, test results, certification of test results and operation by such representatives has been approved.
6. For repairs of unoccupied City fiber conduit systems, the Contractor shall repair, clean and mandrel test the conduit systems in the presence of a Communication Maintenance representative.
7. All pull boxes/vaults shall be provided with a 5/8" by eight foot ground rod and acorn, driven vertically in the corner with six inches of rod exposed above the top of the drainage rock.
8. The absolute maximum length between pull boxes or vaults shall not exceed 600 feet.
9. Communications conduit between pull boxes/vaults shall have a maximum deflection of 270 degrees.

10. Communications conduit shall be buried a minimum of 36" to the top of the conduit below finished grade.
11. Communications conduit shall be 4" schedule 40 PVC.
12. All bends 45 degrees and larger shall be rigid galvanized steel sweeps 12 times the conduit diameter or 48" radius, double wrapped with 10 mil PVC tape.
13. All conduits not occupied by innerduct and tracer wire shall have an unspliced unknotted 2500 pound test 22AWG detectable mule tape installed and secured with 4' slack at each pullbox.
14. All conduit shall be capped and covered with aggregate bedding material, or encased after each day's work to prevent shrinkage and other displacement of the conduit.
15. All materials and appurtenances called out on the plans or required for a complete system shall be new. No used or refurbished items or materials shall be allowed.
16. If there is any conflict among the plans, special provisions, and/or the standard details or specifications of the City of Tucson, or any conflicts within the documents cited above, the higher standard shall apply.
17. Upon project completion, the Contractor shall supply new blueprints and electrically formatted drawings, which reflect all changes and "asbuilt" information

Project Managerial Requirements for Private Communications Projects in City Right-of-Way

Design shall conform to sections 17000 and 975, Telecommunications Infrastructure. Project Managers shall instruct their consultant designers to verify that any written specifications be formatted as applicable to each project such that there is no room for misinterpretation on the part of any contractor or field inspector. Although Project Managers and their Consultants may import the content of these requirements and guidelines into their project designs, said requirements and guidelines are no substitution for due diligence in design, procurement, and construction. **Details and specifications shall reflect actual project conditions.**

For the convenience of all Project Managers, the section entitled “Project Execution Requirements for Private Communications Projects in City Right-of-Way” has been broken out for distribution to design consultants. However, it is the Project Manager’s responsibility to verify that any work delegated to outside consultants is performed in compliance with these City of Tucson Standards.

Project Managers shall coordinate with the City of Tucson Communications Engineering (CE) Division to determine the optimum routing of the City fiber conduit. Final cost estimation for said connections shall be detailed as a part of the subject project.

CE shall be included in the review process for all private projects executed in City Right-of-Way. It shall be the ultimate responsibility of the Project Manager to insure that all CE comments are conveyed to any designer, and are properly addressed.

Project Construction Administrators shall coordinate with CE during the construction period. This coordination shall include a discussion of all system modifications, and the schedule of inspections and system testing. All tests shall be witnessed by a CE representative. Final acceptance of the project shall not be issued until such time that CE or its representative approves and accepts the City fiber conduit system. The representative of CE observing the testing of the conduits may install a tag labeled “DEDICATED CITY OF TUCSON COMMUNICATION CONDUIT. CONTACT TECHNICAL PLANNING AND RESOURCES DIVISION BEFORE USING.” when the conduit run has satisfactorily passed all testing. No party other than CE shall remove said plug and label once it is installed.

Upon project completion, Project Manager shall verify that the Contractor has supplied new blueprints and electrically formatted drawings which reflect all changes and “asbuilt” information.

Project Execution Requirements for Private Communications Projects in City Right-of-Way

The communications/data section of specifications manual shall be numbered separately and distinctly from other sections. Format shall follow the section entitled "Section 975 – Telecommunications Infrastructure". "Details" have also been incorporated into City of Tucson (City) requirements for private projects in City Right-of-Way.

As part of each submittal, Communications Engineering (CE) shall be furnished with a tabulation of the following system information.

- (A) The station and offset of each pull box and vault.
- (B) The total length of each conduit run between pulling points.
- (G) The total degree of bends of all vertical and horizontal bends between pulling points.
- (H) The latitude and longitude of the centerline of the pull boxes and vaults.
- (E) Specific stub-out locations proposed for each pullbox and vault.

The design of the conduit system shall adhere to TIA/EIA 569B standards, TIA/EIA 758A standards, and shall accommodate the cabling requirements of TIA/EIA 568-B.1, 568-B.2, and 568-B.3 standards. Design and construction shall also comply as applicable to the Pima County/City of Tucson Standard Specifications and Details for Public Improvements and to the Tucson Water Standard Specifications.

The plans shall be prepared using the drafting standards of the Department responsible for the project. Plans depicting installations exterior to buildings shall be drafted in accordance with Pima County/City of Tucson Standard Detail Numbers 100 and 101. The conduit shall be clearly indicated with respect to its horizontal and vertical alignment.

The alignment of the conduit shall follow the general horizontal alignment of new water lines, street lighting and traffic signal conduits, or other underground utilities to the fullest extent possible. The utilization of a joint trench shall be employed as much as practicable. When street lighting or traffic signal conduit is encased in concrete, the fiber optic conduit shall be encased in concrete also. When the alignment of the trenching for the other utilities does not allow for the installation of the City fiber conduit, the conduit shall be installed in a separate trench.

The absolute maximum length of the conduit between pull boxes or vaults shall not exceed 600 feet. A continuous, no knots or splices, 2500# rated pull strength traceable mule tape shall be installed for the entire length of each conduit run. All conduit ends shall be capped. Each pullbox shall be provided with a 5/8" by eight foot ground rod and acorn, driven vertically in the corner with six inches of rod exposed above the top of the drainage rock.

When installed adjacent to water mains, the conduit shall be encased in Controlled Low Strength Material (CLSM). The conduit shall be supported on plastic spacers capable of preventing displacement of the conduit during the placement of the CLSM. During the

placement of the encasement material, the conduits shall be tied down to prevent the conduit from floating. The minimum cover on all sides of the conduit shall be 3 inches.

In all areas where the depth of cover above the conduit is less than 36" to the top of the conduit, the conduit shall be encased in concrete. The concrete encasement shall be a minimum of Class B (2,500 PSI) in accordance with Pima County/City of Tucson Standard Specifications and provide a minimum cover on all sides of the conduit of 3 inches.

When the conduit is installed in a joint trench with a water main, the bedding and shading material shall be aggregate bedding material meeting the specifications for the water main. The conduit shall be installed at an invert equal to, or above, that of the water line and offset from the water line as indicated on the Standard Details (Appendix B). The selection of the location of the conduit shall be approved by Tucson Water. The conduit(s) shall generally be installed at a uniform depth of cover. However, when the vertical alignment of the water main offers a smoother profile for the conduit, the conduit(s) may follow the general alignment of the water main. At crossings of other utilities, where the water main is rolled under another utility line, effort(s) shall be made to maintain the vertical alignment of the conduit. In cases where it is impossible to maintain the alignment of the conduit at the utility crossing, the grade of the conduit shall be transitioned using the minimum number and the longest radius bends. To accomplish this, the water system design shall consider the use of 11-1/4 degree bends, or 22-1/2 degree bends for the water line.

The horizontal and vertical alignment of the conduit system shall be the straightest alignment feasible. The design shall minimize horizontal and vertical drift in the conduit runs. Transitions and bends shall be made using the longest radius possible. Bends shall not be installed unless absolutely necessary. The sum of all horizontal and vertical bends shall not exceed 270 degrees in any conduit run. Bends with a radius of 500 feet, or greater, may be excluded from this criterion.

Unless otherwise approved, all conduit shall be 4 inch, schedule 40 PVC conduit. All bends 45 degrees and larger shall be rigid steel conduit, having a minimum radius of 12 times the nominal diameter of the conduit. The exterior of the steel bends shall be double wrapped with 10 mil PVC tape. In special cases, such as in association with borings, rolled pipe (HDPE) may be utilized when approved by the City Construction Representative and the CE Representative. The number and size of the HDPE will be selected based on the specifics of the location.

Conduit with integral innerduct shall be accepted as an alternate to the 4" PVC, with rigid steel bends and its related innerduct installed separately. Such conduit shall meet the requirements of Section 975.

Pull boxes shall be installed at the termini of each project, at locations within the conduit system as required to meet the recommended maximum conduit length and the maximum degree of bends, and at locations required to facilitate the connection to existing and future conduit runs. Pull boxes shall be constructed and installed according to the Pima County/City of Tucson

Specifications and Details for Public Improvements, Number Seven Pullbox with Extension. The boxes shall be furnished with a lockable, or bolted, cover labeled "communications".

In the selection of pull box locations, consideration shall be given to potential location of future City fiber optic conduit runs intersecting the project. At all locations where existing, or future, conduit runs cross the project, a pull box shall be located near the point of intersection. At all locations where new conduit crosses an existing City fiber conduit, a pathway shall be provided between the conduit runs. At locations of future conduit runs, a conduit stub-out shall be installed along the future alignment, to a location which is outside of the limits of any future pavement. Pull boxes shall be located in the vicinity of City facilities scheduled to be connected to the City fiber system. When pull boxes are located near a signalized intersection, the pull box shall be located as near as practicable to the Control Cabinet.

For Rio Nuevo Roadway work, all peripheral equipment associated with cable TV (video), phone service (voice), or data (Internet) shall be installed in an unobtrusive, discreet, and disguised manner. If at all possible, such devices shall be buried. Where this is not possible, communication devices must then be either hidden from public view, or disguised as a natural part of the environment (such as a rock or boulder, natural vegetation, etc.) or building. Hidden or disguised equipment must not interfere with pedestrian flow or block scenic views, disturbing the aesthetics of the area. Equipment areas should not be fenced unless such fencing is installed to meet Code requirements or standard design practice as applicable to life safety issues; in such cases this fencing shall meet the intent of this paragraph in its aesthetic presentation. The equipment must not emit detectable noises or sounds unless they are placed far enough from pedestrian traffic flow that the noise is undetectable. The telephone number for Graffiti Abatement shall be discreetly posted toward the bottom of the equipment. It shall be the responsibility of any vendor or provider to periodically check equipment to ensure that it complies with these standards. Noncompliant vendors may be fined or directed to relocate or remove equipment. Obsolete or unused facilities which have not served a customer for 90 days shall be removed in a timely manner. Cost of removal shall be the responsibility of the vendor or provider.

All drawings shall include the following general notes:

WIDE AREA NETWORK (WAN) CONDUIT SYSTEM GENERAL NOTES:

1. All existing City fiber facilities shall be protected in-place unless specifically noted otherwise on the construction documents. No existing City fiber optic conduit system or cable shall be altered in any way without the written approval of the City Communications Engineering Division.
2. All new City fiber conduit systems shall be cleaned and mandrel tested by the contractor in the presence of a Communications Engineering (CE) representative. Provide 72 hour advance notice to Bobby Sweet at 419-3459.

3. Conduit ends shall be capped when work is not in progress. RGS sweeps terminating in pull boxes shall have a plastic bushing installed.
4. It shall be the sole responsibility of the Contractor to repair all existing City conduit systems and appurtenances damaged by construction. Immediate notification of any damaged existing conduit system, whether occupied or unoccupied, shall be reported to the Construction Administrator and the Communication Maintenance Division, at 791-4634 Monday through Friday between 7:30am to 4:30pm or 791-4830 after hours and weekends.
5. For repairs of occupied City fiber conduit systems, the Contractor shall repair, clean and mandrel test the conduit systems in the presence of a Communication Maintenance representative. The contractor shall install, re-terminate, and test new approved optical fiber cable as directed by the Communication Maintenance representative. The Contractor shall present such representatives with test results, in booklet form and ASCII format, with one licensed version of the original test equipment software, which will allow the City to view the test results as the software was designed. Acceptance of the work shall not occur before all documentation, test results, certification of test results and operation by such representatives has been approved.
6. For repairs of unoccupied City fiber conduit systems, the Contractor shall repair, clean and mandrel test the conduit systems in the presence of a Communication Maintenance representative.
7. Each pullbox/vault shall be provided with a 5/8" by eight foot ground rod and acorn, driven vertically in the corner with six inches of rod exposed above the top of the drainage rock.
8. The absolute maximum length between pull boxes or vaults shall not exceed 600 feet.
9. Communications conduit between pull boxes/vaults shall have a maximum deflection of 270 degrees.
10. Communications conduit shall be buried a minimum of 36" to the top of the conduit below finished grade.
11. Communications conduit shall be minimum 4" schedule 40 PVC.
12. All bends 45 degrees and larger shall be rigid galvanized steel sweeps 12 times the conduit diameter or 48" radius, double wrapped with 10 mil PVC tape.
13. All conduits not occupied by innerduct and tracer wire shall have an unspliced unknotted 2500 pound test 22AWG detectable mule tape installed and secured with 4' slack at each pullbox.
14. All conduit shall be capped and covered with aggregate bedding material, or encased after each day's work to prevent shrinkage and other displacement of the conduit.

15. All materials and appurtenances called out on the plans or required for a complete system shall be new. No used or refurbished items or materials shall be allowed.
16. If there is any conflict among the plans, special provisions, and/or the standard details or specifications of the City of Tucson, or any conflicts within the documents cited above, the higher standard shall apply.
17. Upon project completion, the Contractor shall supply new blueprints and electrically formatted drawings, which reflect all changes and “asbuilt” information

Rio Nuevo Planning and Design Objectives

On a long-term planning horizon, the City of Tucson (City) will be involved in the execution of such developments as Rio Nuevo. It is important to establish a policy of overall uniformity and compatibility among facilities within in the Development, and as they articulate with other institutional facilities. Implementation of any requirements and guidelines shall commence at the programming stage, and be applied with thoroughness and consistency throughout the conceptual, design, and construction phases.

Elements of the communications system which shall be addressed are:

- Integration of the City fiber Underground Communications System with the master plan layout of all utilities serving the Project Area. This shall be executed as soon as possible in the planning process, with provisions for future growth and expansion. Joint use of trenches/utility tunnels shall be employed within the context of individual backfill and separation, and other requirements for each serving utility. The ideal approach would be to identify a single corridor to serve as a conveyance for all utilities, including but not limited to telecommunications, heating and cooling, electrical, gas, and water. Access points for repair and maintenance shall be coordinated as optimally as possible for all serving utilities.
- Interconnection of all facilities of any significance to the City's Regional Communication System.
- Intra-building Local Area Network (LAN).
- Assurance that all buildings of significant size be equipped with radio coverage sufficient to allow the provision of police, fire, medical, and other critical services.
- Identification and dedication of appropriate sites for antennae and other wireless communications devices, as soon as possible in the planning process. Cellular towers to be built in the Rio Nuevo area must be located in designated locations to be determined. Rooftops of buildings in Rio Nuevo may be used for the placement of antennae and dishes. However, cellular towers and antennae placements must be submitted to City's Communications Engineering (CE) Division, and shall be in compliance with the City's Land Use Code. Additionally, all such structures on City property shall go through the City's telecommunications lease process administrated by its Information Technology Department. Rooftop antennae must be disguised or hidden from public view from the ground. Methods for hiding or disguising such equipment include hiding them behind radio frequency (rf) transparent rooftop parapets or other structural components or placing them toward the center of a rooftop. Antenna or dish size shall be kept to a minimum and larger equipment will be prohibited. Equipment shelter size shall also be kept to a minimum of height and footprint. Size of antennae, dishes and equipment shelters will be at the discretion of the City. Obsolete or unused facilities which have not served a customer for 90 days shall be removed in a timely manner. Cost of removal shall be the responsibility of the vendor.
- There shall be no telecommunications overhead wires or optical fiber. All such infrastructure will be underground.

Rio Nuevo Execution Requirements

Developers, Project Managers, and their representatives for Roadway and Architecture/Engineering projects shall instruct their consultant designers to verify that any written specifications be formatted as applicable to each project such that there is no room for misinterpretation on the part of any contractor or field inspector. Although such consultants may import the content of any requirements or guidelines elsewhere in this document into their project designs, said requirements and guidelines are no substitution for due diligence in design, procurement, and construction. Details and specifications shall reflect actual project conditions.

Developers, Project Managers, and their representatives shall comply with the requirements of Sections of this document entitled “Rio Nuevo General On-Site Design Requirements”, “Details”, “800 Mhz In-Building Amplification System Requirements”, and the requirements of this section, as applicable to their specific projects. Specifications for Roadway projects shall conform to the Section entitled “Section 975 - “Telecommunications Infrastructure: DOT Format.” Specifications for Architecture/Engineering projects may refer to the Section entitled “Section 17000 – Telecommunications Infrastructure: CSI Format.” Any conduit, pull boxes, or vaults installed in either of the above project categories shall be installed in conformance with the “Details” elsewhere in this document. Customers and end users in facilities constructed as Architecture/Engineering projects may find the Section entitled “For City Architecture & Engineering Division End Users and Customers” to be helpful.

Developers, Project Managers, and their representatives for Roadway and Architecture/Engineering projects shall coordinate with the City of Tucson Communications Engineering (CE) Division to determine the optimum connection point and routing to the City fiber conduit system. Final cost estimation for said connections shall be detailed as a part of the subject project. For the purposes of site selection, it may be helpful to access the web site <http://dot.ci.tucson.az.us/mapcenter/>, select “TDOT Maps”, and view “Fiber Optic”.

In the selection of pull box locations, consideration shall be given to potential location of future City fiber optic conduit runs intersecting the project. At all locations where existing, or future, conduit runs cross the project, a pull box shall be considered near the point of intersection. At all locations where new conduit crosses an existing City fiber conduit, a pathway shall be considered between the conduit runs. At locations of future conduit runs, a conduit stub-out shall be installed along the future alignment, optimally to a location which is outside of the limits of any future pavement. Pull boxes shall be located in the vicinity of facilities scheduled to be connected to the City fiber conduit system. Another criterion for the selection of pull box locations is the location of traffic signal control cabinets. When pull boxes are located near a signalized intersection, the pull box shall be located as near as practicable to the Control Cabinet.

It is the responsibility of the Developer, Project Manager, and representative of such to coordinate with CE in order to determine whether an underground conduit run on City Property is a candidate for encasement in concrete. Such considerations as the critical nature of the

facility, existence of alternate paths, backup communications paths, and the costs involved will be balanced.

All communications projects containing inter-building and intra-building conduit and wiring and their terminal devices shall be designed by a Registered Communications Distribution Designer (RCDD) with a current Building Industry Consulting Service International (BICSI) registration number stamp.

The design of the conduit system shall comply with BICSI's TDMM, EIA/TIA 569B standards, TIA/EIA 758A standards. They shall accommodate the cabling requirements of TIA/EIA 568-B.1, 568-B.2, and 568-B.3 standards, and shall conform to any applicable Pima County/City of Tucson Standard Specifications and Details for Public Improvements.

CE shall be included in the review process for all private projects executed in City Right-of-Way. It shall be the ultimate responsibility of the Project Manager to insure that all CE comments are conveyed to any designer, and are properly addressed.

The absolute maximum length of the conduit between pull boxes or vaults shall not exceed 600 feet.

The horizontal and vertical alignment of the conduit system shall be the straightest alignment feasible. The design shall minimize horizontal and vertical drift in the conduit runs. Transitions and bends shall be made using the longest radius possible. Bends shall not be installed unless absolutely necessary. The sum of all horizontal and vertical bends shall not exceed 270 degrees in any conduit run. Bends with a radius of 500 feet, or greater, may be excluded from this criterion.

Unless otherwise approved, all conduit shall be 4 inch, schedule 40 PVC conduit. All bends shall be rigid steel conduit, having a minimum radius of 12 times the nominal diameter of the conduit. The exterior of the steel bends shall be double wrapped with 10 mil PVC tape. In special cases, such as in association with borings, rolled pipe (HDPE) may be utilized when approved by the CE Division. The number and size of the HDPE will be selected based on the specifics of the location.

Conduit with integral innerduct shall be accepted as an alternate to the 4" PVC, with rigid steel bends and their related innerduct installed separately. Such conduit shall meet the requirements of Section 975.

All drawings shall include the following general notes:

WIDE AREA NETWORK (WAN) CONDUIT SYSTEM GENERAL NOTES:

1. All existing City fiber facilities shall be protected in-place unless specifically noted otherwise on the construction documents. No existing City fiber optic conduit system or

cable shall be altered in any way without the written approval of the City's Communications Engineering Division.

2. All new City fiber conduit systems shall be cleaned and mandrel tested by the contractor in the presence of a Communications Engineering (CE) representative. Provide 72 hour advance notice to Bobby Sweet at 419-3459.
3. Conduit ends shall be capped when work is not in progress. RGS sweeps terminating in pull boxes shall have a plastic bushing installed.
4. It shall be the sole responsibility of the Contractor to repair all existing City conduit systems and appurtenances damaged by construction. Immediate notification of any damaged existing conduit system, whether occupied or unoccupied, shall be reported to the Construction Administrator and the Communication Maintenance Division, at 791-4634 Monday through Friday between 7:30am to 4:30pm or 791-4830 after hours and weekends.
5. For repairs of occupied City fiber conduit systems, the Contractor shall repair, clean and mandrel test the conduit systems in the presence of a Communication Maintenance representative. The contractor shall install, re-terminate, and test new approved optical fiber cable as directed by the Communication Maintenance representative. The Contractor shall present such representatives with test results, in booklet form and ASCII format, with one licensed version of the original test equipment software, which will allow the City to view the test results as the software was designed. Acceptance of the work shall not occur before all documentation, test results, certification of test results and operation by such representatives has been approved.
6. For repairs of unoccupied City fiber conduit systems, the Contractor shall repair, clean and mandrel test the conduit systems in the presence of a Communication Maintenance representative.
7. All pull boxes/vaults shall be provided with a 5/8" by eight foot ground rod and acorn, driven vertically in the corner with six inches of rod exposed above the top of the drainage rock.
8. The absolute maximum length between pull boxes or vaults shall not exceed 600 feet.
9. Communications conduit between pull boxes/vaults shall have a maximum deflection of 270 degrees.
10. Communications conduit shall be buried a minimum of 36" to the top of the conduit below finish grade.
11. Communications conduit shall be 4" schedule 40 PVC.

12. All bends 45 degrees and greater shall be rigid galvanized steel sweeps 12 times the conduit diameter or 48" radius, double wrapped with 10 mil PVC tape.
13. All conduits not occupied by innerduct and tracer wire shall have unspliced unknotted 2500 pound test 22AWG detectable mule tape installed and secured with 4' slack at each pullbox.
14. All conduit shall be capped and covered with aggregate bedding material, or encased after each day's work to prevent shrinkage and other displacement of the conduit.
15. All materials and appurtenances called out on the plans or required for a complete system shall be new. No used or refurbished items or materials shall be allowed.
16. If there is any conflict among the plans, special provisions, and/or the standard details or specifications of the City of Tucson, or any conflicts within the documents cited above, the higher standard shall apply.
17. Upon project completion, the Contractor shall supply new blueprints and electrically formatted drawings, which reflect all changes and "asbuilt" information

Rio Nuevo General On-Site Design Guidelines

Design. The design of the conduit system shall adhere to TIA/EIA 569B standards, TIA/EIA 758A standards, and shall accommodate the cabling requirements of TIA/EIA 568-B.1, 568-B.2, and 568-B.3 standards.

General Alignment. Where installed along side of other utilities, conduit alignment shall follow the general horizontal alignment of other underground utilities to the fullest extent possible. Utilize joint trenching as much as practicable to reduce the cost associated with trench work. When the alignment of the trenching for the other utilities does not allow for the installation of the City fiber conduit, the conduit shall be installed in a separate trench.

Pull Boxes or Vaults. The absolute maximum length of the conduit between pull boxes or vaults shall not exceed 600 feet. Each pullbox shall be provided with a 5/8" by eight foot ground rod and acorn, driven vertically in the corner with six inches of rod exposed above the top of the drainage rock.

Vertical and Horizontal Alignment. The horizontal and vertical alignment of the conduit system shall be the straightest alignment feasible. The design shall minimize horizontal and vertical drift in the conduit runs. Transitions and bends shall be made using the longest radius possible.

Maximum Bends Between Pulling Points. The sum of all horizontal and vertical bends shall not exceed 270 degrees in any conduit run. Bends with a radius of 500 feet, or greater, may be excluded from this criterion.

Innerduct And Tracer Wire. All 4 inch conduits, except those referred to below as dedicated to Telephone, and CATV shall have 4 (quantity) 1 inch *smoothwall exterior ribbed interior* innerducts with a continuous 1250 pound test mule tape installed in each innerduct, along with 1 (quantity) 10 AWG green continuous nonspliced copper tracer wire installed in the 4 inch conduit.

Watertight Alibi. Watertight Alibi shall consist of a Quadraplex Duct Plug designed to seal around, organize, and support innerduct where it emerges at the top of all risers, pull boxes, and vaults. Fasteners shall be stainless steel. Plug shall support a minimum of 400 lbs of cable, and shall be removable. Jackmoon or equivalent. No chemical seals will be accepted

Blank Duct Plugs. Blank Duct Plugs shall be installed in each individual innerduct where it emerges at the top of all risers, pull boxes, and vaults. Shall be all plastic construction, corrosion proof, water and air tight to 30 psi. Jackmoon or equivalent.

Standard Conduit Requirements. Unless otherwise approved, all Wide Area network (WAN) conduit shall be 4 inch, schedule 40 PVC conduit buried a minimum of 36" to the top of the conduit below finished grade. The number and size of the HDPE will be selected based on the specifics of the location. Pull boxes shall be installed at the termini of each conduit run. In addition to the (2) 4" schedule 40 PVC conduit for the LAN referenced above, (1) 4" schedule 40 PVC conduit shall be installed for cable television (CATV) facilities, and (1) 4" schedule 40 PVC conduit shall be installed to the Entrance Facility (EF) for Telephone, or the current Long Distance Carrier. Coordinate with the Authority Having Jurisdiction (AHJ) for Telephone and CATV conduit routing, terminations, and project-specific requirements.

Concrete Encasement. All conduits installed under roadways and parking lots on City property shall be encased in Class B (2500psi) concrete with a minimum of 3" cover on all sides. All other conduit runs on City property and City Right of Way shall be given serious consideration as candidates for encasement in concrete. Coordinate with CE, who will balance such considerations as the critical nature of the facility, existence of alternate paths, backup communications paths, and the costs involved. Details and specifications shall reflect actual project conditions.

Peripheral Communications Equipment. All peripheral equipment associated with cable TV (video), phone service (voice), or data (Internet) shall be installed in an unobtrusive, discreet, and disguised manner. If at all possible, such devices shall be buried. Where this is not possible, communication devices must then be either:

- Hidden from public view, or
- Disguised as a natural part of the environment (such as a rock or boulder, natural vegetation, etc.) or building.

Hidden or disguised equipment must not interfere with pedestrian flow or block scenic views, disturbing the aesthetics of the area. Equipment areas should not be fenced unless such fencing is installed to meet Code requirements or standard design practice as applicable to life safety issues; in such cases this fencing shall meet the intent of this paragraph in its aesthetic presentation. The equipment must not emit detectable noises or sounds unless they are placed far enough from pedestrian traffic flow that the noise is undetectable. The telephone number for Graffiti Abatement shall be discreetly posted toward the bottom of the equipment.

It shall be the responsibility of any vendor or provider to periodically check equipment to ensure that it complies with these standards. Noncompliant vendors may be fined or directed to relocate or remove equipment. Obsolete or unused facilities which have not served a customer for 90 days shall be removed in a timely manner. Cost of removal shall be the responsibility of the vendor or provider.

800 Mhz In-Building Amplification System Requirements

With the proliferation of wireless technology, more people have become aware of the intermittent problems associated with cellular telephone coverage, particularly within buildings. Radio systems experience similar problems when used in and around large buildings or structures. City services, primarily public safety, routinely use radios to perform life saving operations. Accommodation must be made for reliable public safety radio coverage inside buildings in order to provide those critical services to the public. There are several significant functions which are enabled by providing uninterrupted radio communications capacity inside buildings and within the city limits.

- Public safety needs – police, fire, medical, and other critical emergency services
- Response to major incidents, disasters
- Event coordination
- City worker efficiency – interoperability among departments and with other agencies

There are various factors affecting the quality of radio signals inside buildings. Internal factors include but are not limited to building mass, size, and composition; location of transmitting and receiving devices within a building; windows with reflective coatings; and presence of elevator shafts. External factors include but are not limited to the composition of barriers in the immediate physical location of buildings; building configuration with respect to natural barriers such as mountain ranges and densely foliated trees; terrain variations; and manmade barriers such as other large buildings.

All Project Managers shall coordinate with the Communications Engineering Division (CE) to determine whether mitigating technologies are to be designed and constructed to the end of assuring adequate radio coverage. The list in the above paragraph is intended to provide the Project Manager with some insight into the considerations involved, and is no substitute for proper coordination with the Communications Engineering Division.

Consideration shall be given to signals generated within building core and transmitted outside of building, signals generated outside of building and received from within building core, and signals transmitted and received point-to-point within a structure. The intent is to provide an in-building coverage area reliability of 95%. The radio frequency signal level at the receiver's input for both talk-out and talk-in shall be adequate to support CM 4(DAQ-3.4) voice quality. The coverage shall be based on using portable units on the hip for receive, and held at five (5) foot level for transmit, in each above-ground level floor of the building. The Channel Performance Criteria, defined in TSB-88, within these areas shall be applied to 95% of the area in the presence of noise and interference.

Radio Coverage and Allowed Systems. For purpose of this section, adequate radio coverage is required, and is defined as circuit merit 3 or better and shall include all of the following:

- A minimum signal strength of -95 dbm available in 95% of the area of each floor of the building or structure when transmitted from the transceiver of the 800 MHz trunked communications system;
- A minimum signal strength of -95 dbm received at the transceiver of the 800 MHz trunked communications system when transmitted from 95% of the area of each floor of the building
- The frequency range which must be supported shall be 821-824 MHz and 866-869 MHz; and
- A 100% reliability factor.

Amplification Systems Allowed. Buildings and structures which cannot support the required level of radio coverage shall be equipped with either (a) an internal multiple antenna or radiating cable system bi-directional 800 MHz amplifiers. Bi-directional amplifiers shall include filters to reduce adjacent frequency interference at least 35 db below the National Public Safety Planning Advisory Committee (NASPAC) band. The filters shall be tuned to 825 MHz and to 870 MHz so that they will be 35 db below the NPSPAC frequencies of 824 MHz and 869 MHz respectively. Other settings may be used provided that they don't attenuate the NPSPAC frequencies and further provided that they are not more than one (1) MHz from the NPSPAC frequencies.

Secondary Fiber Optic System. If there is dark fiber present or can be economically installed from the network to the proposed building (use of existing fiber plant or adequate conduit capacity allowing additional fiber runs to be pulled), then a fiber based secondary system with amplification devices as required may be viable and preferred. This determination will be made by CE. If proposed, a fiber-based system shall integrate to existing network infrastructure and management protocols.

Off-Air Repeater. If dark fiber is not present or too expensive to route to the building, in building coverage can be provided through the use of bi-directional amplifiers and distributed antenna system or leaky feeder radiating cable. Extra RF filtering may be required and engineered into the system design to reject unwanted signals.

Upon completion of each installation, the radio system will be tested to ensure adequate two-way coverage within the facility as specified below:

- Each above-ground level floor of the building shall be divided into a grid of approximately twenty (20) equal areas.
- The test shall be conducted using a portable radio such as the City is using at the time of the test for the intended purpose, talking through the transceiver of the 800 MHz trunked communications system.
 - A spot located approximately in the center of a grid area will be selected for the test.
 - The radio will be keyed to verify two-way communications to and from the outside of the building to and from the 800 MHz trunked radio system.

- Once the spot has been selected, prospecting for a better spot within the grid area will not be permitted.
- Each grid area will be tested for transmission/reception; minimum signal strength of -95 dbm. If signal strength fails to meet the requirement, the grid area shall be marked as a fail.
- A maximum of two (2) nonadjacent areas will be allowed to fail the test. In the event that three (3) of the areas fail the test, in order to be more statistically accurate, the floor may be divided into forty (40) equal areas.
 - In such event, a maximum of four (4) nonadjacent areas will be allowed to fail the test.
 - After the forty (40)-area test, if the system continues to fail, the system shall be altered to meet the 95% coverage requirement.
- The gain values of all amplifiers shall be measured and the test measurement results provided as part of required system documentation.

Any management system introduced into the core network for the purpose of remote monitoring, configuration or tuning of the proposed RF amplification system must be compatible with, or be non-intrusive to, existing management platforms.

Vendor equipment shall, where applicable, meet the standards set by the IETF, ITU-T, ISO, IEEE, and UL. All Ethernet devices provided by the vendor shall meet at a minimum IEEE 802.3 and 802.3I specifications.

All vendor supplied devices shall accurately process date/time data. Furthermore, when inter-operating with other vendors' products, all vendor supplied devices shall accurately process date/time data interchanged with other vendor's products to the extent that the other vendor's products properly conform to year 2000 requirements.

The Contractor shall provide documentation in both machine-readable formats (Microsoft Project, Excel, Word, AutoCAD, and others upon approval by City and in limited volume (two sets) on hardcopy as required herein.

Hardware, firmware, software, and configuration of monitoring shall operate within the stated environment and shall interoperate with the existing network infrastructure and radio communications system without any loss of performance or functionality as defined by the requirements and standards listed to the extent that the other vendor's products properly conform to these requirements and standards.

Section 17000 – Telecommunications Infrastructure: CSI Format

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Materials and equipment shall be the standard products of the manufacturer regularly engaged in the manufacture of the products and shall be of the manufacturer's latest standard product design that has been in satisfactory use for at least 2 years prior to bid opening.

- ANSI C2: 1996 TIA-2; Errata National Electric Safety Code
- ANSI/EIA/TIA-568-B: Commercial Building Telecommunications Cabling Standard
- ANSI/EIA/TIA-569B: Commercial Building Standards for Telecommunications Pathways and Spaces
- ANSI/EIA/TIA 606: Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
- ANSI/EIA/TIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
- ANSI/EIA/TIA-758A: Customer Owned Outside Plant Telecommunications Cabling Standard
- NESC/IEEE C2 2002: National Electric Safety Code
- ANSI/NFPA 70: (2002) National Electric Code
- EIA-455-A: Standard Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors Connection and Termination Services, and Other Fiber Optic Components
- EIA-455-13: Visual and Mechanical Inspection of Fibers, Cables, Connectors, and/or Other Fiber Optic Devices
- EIA/TIA-455-60: Measurement of Fiber or Cable Length using an OTDR
- EIA/TIA-455-61: Measurement of Fiber or Cable Attenuation using an OTDR
- EIA/TIA-455-168: Chromatic Dispersion Measurement of Multi-mode Graded-Index and Single-Mode Optical Fibers by Spectral Group Delay Measurement in the Time Domain
- EIA/TIA-472A-D: General Specifications for Fiber Optic Cables
- EIA/TIA-492X: Generic Specifications for Single-/Multi-Mode Fiber Optic Cables
- EIA/TIA-526-X: Optical Power Loss Measurement of Installed Fiber Optic Plant
- EIA/TIA-TSB 67: Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems
- IEC 874-14: Sectional Specification for Fiber Optic Connector Type SCFOC/2.5
- ISO/IEC IS 11801: Generic Cabling for Customer Premise
- SP-2840A: Measurement of Crosstalk
- TSB-36A: Crosstalk and Attenuation Specifications for Connectors
- TSB-40A: Connectors Specifications
- UL 444 & 13: Adopted Tests and Follow-Up Service Requirements for the Optional Qualification of 100-Ohm Twisted Pair

- AF-PHY-0015.000: ATM Forum Standard for 155Mb/s ATM over Category Five
 - BICSI: Current version of the Telecommunication Distribution Methods Manual.
- B. The installation of the underground conduit system shall adhere to TIA/EIA 569B standards, TIA/EIA 758A standards, as well as the latest editions of applicable EIA, TIA, ANSI, ASTM Standards and the Pima County/City of Tucson Standard Specifications and Details for Public Improvements. In the event of a conflict among any of the above and the project specifications, the higher standard shall apply.

PART 2 – PRODUCTS AND MATERIALS

2.1 GENERAL

- A. Materials shall be new, standard in every way, and satisfactory to the Designer.

2.2 CABLING

- A. All outside plant (OSP) cable shall be gel-filled unless pre-approved by Communications Maintenance.
- B. All horizontal copper cabling, including workstation cabling, shall be plenum rated, if the environment requires it. All optical fiber cable, riser copper cable, and innerduct shall be plenum rated, if the environment requires it.
- C. Copper

1. **Inter-Building Cable.** Building entrance and building exit terminals shall be terminated on protectors described elsewhere. Copper cable shall be AWG 24 solid copper conductors insulated with gel filling rated PE-89 or better. Cable shall have a maximum average DC resistance of 8.7 Ω /Km, maximum average DC resistance unbalanced at 1.5%. Mutual capacitance at 1khz shall be 5.15 pf/Km with a maximum unbalanced capacitance (pair to ground) of 57.4 pf/Km. Cable shall meet or exceed 10BASE-T testing requirements for attenuation, impedance, and worst pair loss (NEXT).
2. **Riser Cable.** Riser cable between TC's shall be NEC Article 800 Type CMP multi-pair AWG24 rated for Category Three operation.
3. **Horizontal Cable.**
 - a. **Data.** Copper station cable between the station jack and the distribution blocks shall be ISO/IEC 11801 'D' or EIA/TIA 568-B Category Five Extended.
 - 4 pair AWG24 rated for up to 350 MHz operation
 - Powersum NEXT minimum 40db @ 100mhz

- NEXT minimum 42 db @ 100 MHz
 - Attenuation 0,4 db @ 100 MHz
 - Return Loss 18db @ 100 MHz
 - ACR balanced across all frequencies 1-160mhz
- b. **Voice.** 25 Pair AWG24 rated for up to 20 MHz operation
- c. **Workstation cable.** All workstation cable shall be Plenum cable 4X0 construction. All cable shall be as manufactured by an ISO 9002 compliant manufacturer.
4. **Coax.** Coaxial cable shall be application specific per the manufacturers guidelines.
5. **Grounding Conductor.** Grounding conductors shall be copper and meet all requirements of the National Electrical Code articles 250 and 800.

D. Fiber Optic Cable

1. Intra-Building

Fiber optic cable shall be suitable for riser, tray and indoor general purposes. Cable shall be Applicable Flame Test UL 1666 listed OFNR, or OFNP, as applicable. Cable shall be dielectric and of tight buffer construction. Finished cables shall conform to the applicable performance requirements of Table 8-6 and 8-7 in the insulated Cable Engineers Association, Inc. (ICEA) Standard for Fiber Optic Premises Distribution Cable (ICEA S-83-596).

2. Inter-Building

- a. Fiber optic cable shall be suitable for Duct tray and outdoor/indoor general purposes. Cable shall be RUS listed 7CFR1755.900, ANSI/CEA S-87-640-1992 as applicable, Cable shall be dielectric and of loose tube construction.
- b. Fiber Optic Backbone Cable shall be Multi-mode and Single-mode optical fibers contained in a cable.

E. Fiber Characteristics

1. Multi-Mode

- a. Fiber shall be graded index optical glass meeting EIA/TIA-492AAAA-1989
- b. Core diameter, shall be $62.5 \pm 3.0 \mu\text{m}$.
- c. Cladding diameter shall be $125.0 \pm 2.0 \mu\text{m}$.

- d. Core-to-cladding offset shall be $\geq 3.0 \mu\text{m}$.
- e. Cladding non-circularity: $< 2.0 \%$ Defined as: (Minimum Cladding Diameter)
- f. (Maximum Cladding Diameter) x 100
- g. Core non-circularity: $\leq 5 \%$ Defined as: (Minimum Core Diameter)
- h. (Maximum Core Diameter) x 100
- i. Attenuation Uniformity: No point discontinuity greater than 0.20 dB at either 850 nm or 1300 nm
- j. Numerical Aperture: 0.275 ± 0.015

2. Single-Mode

- a. Fiber shall be dispersion unshifted optical glass.
- b. The core diameter, if an addressable parameter, shall be $8.5 \mu\text{m}$. If the core diameter is not addressed, then the mode field diameter shall be $10 \mu\text{m}$ plus or minus $1 \mu\text{m}$.
- c. The cladding diameter shall be $125 \mu\text{m} \pm 1.0 \mu\text{m}$.
- d. The core-cladding offset shall be $\leq 0.8 \mu\text{m}$.
- e. Cladding non-circularity: $< 1.0 \%$ Defined as: (Minimum Cladding Diameter)
- f. (1-Maximum Cladding Diameter) x 100.
- g. The attenuation Uniformity shall have no point discontinuity greater than 0.10 dB at either 1310 nm or 1550 nm.
- h. Attenuation at the Water Peak: The attenuation at $1383 \pm 3 \text{ nm}$ shall not exceed 2.1 dB/km.
- i. Cutoff Wavelength: The cabled fiber cutoff wavelength (λ_{ccf}) shall be $< 1260 \text{ nm}$.
- j. Mode-Field Diameter: $9.30 \pm 0.50 \mu\text{m}$ at 1310 nm, $10.50 \pm 1.00 \mu\text{m}$ at 1550 nm.
- k. Zero Dispersion Slope (So): $\leq 0.092 \text{ ps}/(\text{nm}^2 \bullet \text{km})$.
- l. Fiber Polarization Mode Dispersion (PMD): $\leq 0.5 \text{ ps}/\sqrt{\text{km}}$.
- m. The maximum dispersion shall be $\leq 3.2 \text{ ps}/(\text{nm} \bullet \text{km})$ from 1285 nm to 1330 nm and shall be $< 18 \text{ ps}/(\text{nm} \bullet \text{km})$ at 1550 nm.

3. Attenuation

- a. **Multi-mode:** The optional attenuation of each Multi-mode optical fiber in the reeled cable shall be not greater than 3.0/0.7 dB/km within a peak emissive region of 850/1300 nm. The attenuation shall be measured on completed cable reel; length, and normalized linearly to 1 km. The measurement method shall be in accordance with EIA 455-46A or EIA 455-53A
- b. **Single-mode:** The optical attenuation of each Single-mode optical fiber in the reeled cable shall be not greater than .4/. 3 dB/km within a peak emissive region of 1310/1550 nm. The attenuation shall be measured on completed cable reel length, and normalized linearly to 1 km. The measurement method shall be in accordance with EIA 455-46A or EIA 455-53A.

4. Bandwidth

Multi-mode. Optic fiber within the cable (reeled) shall have its bandwidth measured between 3 dB optical power points, as compared to a reference signal, from a light source with a peak optical emissive region of 850 to 1300 nm. The effective system bandwidth of at least 1 GHz-km is required and minimum normalized bandwidth shall be $\geq 160/500$ MHz/km at 850/1300 nm. The effective system bandwidth is the bandwidth length product calculated from the measured bandwidth multiplied by the cable length raised to the negative length dependence factor (or gamma factor). Gamma shall be in the range of 0.85 to 0.9. The bandwidth measurement shall be in accordance with EIA 455-54A FOTP-30 EIA 455-51 time domain.

5. **Dispersion.** The maximum dispersion shall be ≤ 3.2 ps/(nm•km) from 1285 nm to 1330 nm and shall be < 18 ps/(nm•km) at 1550 nm.
6. All optical fibers shall be proof tested by the fiber manufacturer to a minimum load of 0.7 GN/m² (100 kpsi).
7. All fibers in the cable must be usable fibers and meet required specifications.
8. Contractor shall provide written certification from the manufacturer that all fiber optic cable contain no splices in the glass and that the fiber was manufactured from a single piece of glass as provided by the original manufacturer. Contractor shall provide manufacturer test results in the form of a cable data report, containing attenuation at all applicable wavelengths, and refractive indices, for all pairs.
9. Non-Plenum Applications – Applicable Flame Test: UL 1581 and UL 1666.
10. Plenum Applications – Applicable Flame Test: UL910 (NFPA 262-1994).
11. Cable manufacturer shall be ISO 9001 registered.

2.3 CONDUITS - ABOVE GRADE

- A. Minimum conduit size shall be 3/4 inch.
- B. Conduits 1-1/2 inches and smaller shall be steel electrical metallic tubing (EMT). EMT shall be galvanized on the outside and coated on the inside with a smooth, hard finish of lacquer, varnish or enamel. EMT shall comply with UL Standard UL797 and ANSI C80-1. EMT couplings and box connectors for EMT shall be of the throated steel compression gland type.
- C. Conduits 2 inches and larger shall be galvanized rigid steel. RGS conduit shall be hot-dipped, galvanized steel with zinc coating or corrosion resistant lacquer on the inside, and

shall comply with Underwriters' Laboratories Standard UL6 and ANSI C80-1. Fittings shall be threaded, water and concrete-tight.

- D. All conduits subject to mechanical injury or exposed in wet locations shall be rigid galvanized steel.
- E. Raceway shall be either Wiremold 6000, 3000, 700 series metallic, or Composite Plastic raceway including all components intended for a proper professional installation as required. Outlet Boxes, where required, shall be metallic or plastic and of a design for use with the raceway. All raceways must comply with all 568B standards, specifically the minimum 1-inch bend radius. All 90-degree turns in raceway must be provided with the appropriate junction to ensure non-violation of bend radius. All raceway shall be painted to match its environs.

2.4 CONDUIT SYSTEM – UNDERGROUND

2.4.1 Polyvinyl Chloride (PVC) Conduit. All conduit shall be listed by UL and conform to NEC standards. Unless otherwise specified, all conduit to be installed underground or installed in concrete structures shall be 4-inch diameter, rigid Polyvinyl Chloride (PVC) Non-Metallic Conduit. The PVC conduit shall be schedule 40, heavy wall, sunlight resistant, manufactured from high impact material and shall be rated for use at 90 degrees centigrade. The conduit shall meet the specifications of UL 651 and NEMA TC-2, and furnished with interface fit bell ends. Fittings shall be schedule 40 PVC, meeting the specifications of NEMA TC-3 and UL 514.

Conduit with Integral Innerduct shall be accepted as an alternate to the 4" PVC, with innerduct and rigid steel bends installed separately. Conduit with Integral Innerduct shall be of schedule 40 PVC in modular, slip fit lengths. Shall have pre-lubricated innerducts with internal spacers and which expand and contract at the same rate as the outerduct. Shall have anti-reversing gaskets, and an o-ring gasket at bell base. Shall have inward tapering holes on coupling body for easy assignment, printed indication such as "Install Print Side Up" to keep system straight during installation, and marked innerduct and marked hole on coupling body to insure proper innerduct alignment and allow crews to work from opposite directions. Bends shall be flexible and engineered to be cut-through resistant. Carlon Telecom Systems Multi-Gard or equivalent. All integral innerducts shall have a unspliced unknotted 1250 pound test detectable mule tape installed.

2.4.2 Solvent Cement for Polyvinyl Chloride (PVC) Conduit and Couplings. All solvent cement shall meet the requirements of ASTM D 2564. The cement shall be of a medium or heavy-bodied cement capable of making watertight joints. The cement and primer shall be of a type recommended by the manufacturer of the conduit.

2.4.3 Rigid Steel Conduit Sweeps. Conduit sweeps shall be listed by UL and conform to NEC standards. The bends shall be steel, hot dipped zinc coated, meeting the requirements of UL 6 and ANSI C80.1, and shall carry the Underwriters Laboratory label. Non-thread couplings shall not be used. Sweeps shall have a minimum radius of 12 times the nominal

diameter of the conduit. Steel conduit sweeps shall have a factory applied 40 mil PVC coating or be doubled (half overlap) wrapped with a 10 mil PVC plastic tape specifically manufactured for corrosion protection of metallic conduits installed below grade.

2.4.4 Flexible Conduit. When specifically indicated on the plans and where approved by the engineer, flexible solid wall direct bury conduit may be used. The conduit shall be manufactured of Polyvinyl Chloride (PVC), or Polyethylene (PE) plastic. The conduit shall be specifically manufactured for direct buried fiber optic raceway systems and shall be Carlon “Optic-Gard PE” conduit, or approved equal. Flexible conduit shall not be utilized for making bends in conduit system. Connection between the flexible conduit and conduits of other materials shall be made with a watertight transition coupling manufactured for the specific type of material.

2.4.5 Plastic Conduit Spacers. Spacers shall be constructed of Polyvinyl Chloride (PVC) or other non-metallic material. The spacers shall be vertical and horizontal interlocking and provide a minimum of 3-inch clearance between conduits. Base spacers shall be provided with a wide base plate to provide solid support on the bottom of the trench. The base spacers shall provide for a minimum clearance of 3 inches between the bottom of the trench and the conduit. The spacers shall be tied down to prevent displacement during concrete encasement.

2.4.6 Aggregate Bedding Material. Aggregate material for bedding shall meet the gradation indicated in the specifications and on the drawings for the subject project. The plasticity index shall also conform to the specifications under which the subject project is designed and constructed.

2.4.7 Detectable Warning Tape. An electronically detectable 6” Fiber Warning tape shall be installed 18” above the conduit. Tape shall be acid and alkali-resistant polyethylene film, 6 inches wide with a minimum thickness of 0.004 inch. The tape shall have a minimum strength of 7500 PSI lengthwise and 1,500 PSI crosswise. The tape shall be manufactured with integral wires, foil backing, or other means to enable its detection by a metal detector when the tape is buried up to a depth of 3 feet deep. The tape shall be orange in color and have the following continuous inscription, “CAUTION - FIBER OPTIC CABLE BURIED BELOW”. The inscription shall be 2-inch black letters.

2.4.8 Backfill Material. The backfill material shall conform to that of the subject project.

2.4.9 Tracer Wire. The cable and wire shall be listed by UL and conform to NEC standards. The wire shall be stranded continuous unspliced 10 AWG CU, rated for 600 volts, and shall be type THW or XHHW. The color of the wire shall be green. The wire shall be of the required length to eliminate all splices within the conduit.

2.4.10 Electronic Marker. An electronic marker, 3M model 1255 mini-marker shall be placed by the Contractor at the location of any capped conduit not in a building or a pullbox.

2.4.11 Pull Boxes. Communications pull boxes shall be molded high density polyethylene base and polymer concrete cover. The pullbox shall be gray in color. The pullbox shall have a bolt-down cover secured by a minimum of two (2) recessed hex-head bolts. The pullbox cover shall have the word "COMMUNICATIONS" written on it in permanent raised, stamped or engraved lettering. Pull boxes shall be open base. The pullbox base shall have two knockouts on each end and side. Pull boxes may be extended by means of an extension or spacer. Contractor shall provide all necessary collars, extensions, hardware, sealant, and conduit caps. All conduit entrances shall be sealed. The assigned pullbox number shall be painted on the box at the time of installation. Chipped, cracked, or otherwise damaged boxes and covers will not be accepted.

2.4.12 Vaults. Communications vaults shall be UL listed. Vault base shall be pre-cast concrete with a minimum thickness of 4". Vault cover shall be pre-cast concrete with a minimum 36" x 36" galvanized steel locking lid secured by a minimum of one (1) recessed hex-head bolt. The cover lid shall have "COMMUNICATIONS" written on it in permanent raised, stamped or welded lettering. The vault base and vault cover shall be gasketed and weather proof. Vaults shall have a minimum outside dimension of 48" long by 48" wide by 50" high with a minimum thickness of 4". The base shall have one (1) 8" diameter by 4" deep sump hole knockout in the floor. The base interior shall have a minimum of one (1) 2 1/2" diameter ground rod knockout in the floor, at a corner; the base interior shall have four (4) 7/8" diameter pulling irons, one centered on each side. The base exterior walls shall have four (4) 36" "C" channels precast in the sides, one on each side; the base exterior shall have four (4) 18" x 18" knockouts, one on each side; and, the base exterior shall have sixteen (16) 4 1/2" diameter knockouts for 4" conduit entrances, four on each side. Contractor shall provide all necessary collars, extensions, hardware, sealant, and conduit caps. All conduit entrances shall be sealed. The assigned box number shall be painted on the box at the time of installation. Chipped, cracked, or otherwise damaged boxes and covers will not be accepted.

2.4.13 Portland Cement Concrete. Concrete shall be Class B meeting the requirements of Section 1006 of the Pima County/City of Tucson Standard Specifications for Public Improvements.

2.4.14 Innerduct. Innerduct shall be PVC and constructed of a smooth walled exterior and a ribbed interior with 1250 pound test muletape installed. No corrugated innerduct will be accepted.

2.4.15 Watertight Alibi. Watertight Alibi shall consist of a Quadraplex Duct Plug designed to seal around, organize, and support innerduct where it emerges at the top of all risers, pull boxes, and vaults. Fasteners shall be stainless steel. Plug shall support a minimum of 400 lbs of cable, and shall be removable. Jackmoon or equivalent. No chemical seals will be accepted.

2.4.16 Blank Duct Plugs. Blank Duct Plugs shall be installed in each individual innerduct where it emerges at the top of all risers, pull boxes, and vaults. Shall be all plastic construction, corrosion proof, water and air tight to 30 psi. Jackmoon or equivalent.

2.5 INFORMATION OUTLETS

- A. Standard Information Outlets shall be EIA/TIA 568B rated for up to 155mhz applications. Information Outlets shall Uniprise UNJ500 series or equal for Wall, Modular Furniture, and other appropriate applications. Black, White, Ivory, Grey with M20AP-246 Blank. The outlet labeled #1 is black, #2 is ivory, #3 is gray, and #4 is white.
- B. Multi-media Outlets shall be a combination of the Standard Information Outlet and duplex SC optical outlets
- C. Wall Phone Outlets shall be Lucent 630B stainless steel or approved equal.
- D. New wall work requires a 4 inch square, deep metal box with a single gang plaster ring, for a four port outlet. A double gang plaster ring shall be installed for an eight port outlet. Surface mounted application shall be weather proof deep Bell boxes. Size of conduits entering all boxes shall conform to the standards with a maximum fill not exceeding 40%.
- E. Each Mechanical Room in a COT facility shall be provided with an information outlet dedicated to the Energy Management Control System (EMCS).

2.6 FACE PLATES

- A. Standard Information Outlet shall be Commscope UNF-FM-4P, color by architect.
- B. Multi-Media faceplate shall be Panduit CFPE10 with CFS2IW. Use appropriate Panduit outlets CJ588SBXX for copper termination.
- C. CATV shall be stainless steel with bulkhead .

2.7 WIRE MANAGEMENT

- A. Wire management panels shall be of horizontal plastic rings mounted above and below the patch panels on the 19" rack. CPI 11752-219 & CPI 11753-219 or equal, placed on both the front and back sides of the rack.
- B. Vertical wire management shall be dual channel metallic CPI 11729-503 or equal, placed between all racks.
- C. Cable tray shall be steel open ladder 12". Cable tray shall be supported each 5', minimum. Cable tray and all associated mounting equipment shall be clear finished.
- D. Fiber jumpers on framework, typically running vertically, shall be protected by finger stock raceway, Panduit or equivalent. Fiber jumpers on racks, typically running horizontally, shall be in suitable fiber cable trough, including elbows with their inner curve swept, couplings, down spouts, and cover.

2.8 RACKS

- A. Floor Racks shall be UL listed 7' x 19" self-supporting EIA channel clear finished with mounting holes on both sides.
- B. Wall Racks shall be 18" deep UL listed 19" wide clear finished and sized appropriately for the devices intended for termination on these racks. All wall mounted racks shall be field cut to size to meet the environment.
- C. Contractor shall ensure a minimum of 24 Single-rack positions available after installation or equipment.
- F. Each rack shall have one Sub System Grounding Bus Bar (SSGB) installed at the top rack position. The SSGB shall be bonded to the Telecommunications Main Grounding Bus Bar (TMGB), referenced in Part 2.17 below, by one of the following methods: bonding the SSGB to a ground bus conductor using a irreversible compression tap connector is preferred; bonding the SSGB directly (home run) to the TMGB is acceptable.
- G. Each rack shall have one minimum 6 outlet power strip CPI or equivalent with minimum 10' power cord installed at the middle rack position

2.9 BACKBOARDS

Backboards shall be a minimum ¾" AC plywood, fire treated finished 'A' side out.

2.10 PATCH PANELS

Data: Patch Panels shall be Uniprise RFE series or approved equal 24 port 19" rack mountable black aluminum.

Voice (Analog) shall be 24 port 1U RJ21<>RJ45 with pins 4,5 active

2.11 VOICE TERMINATION

Voice Termination blocks shall be Lucent or Siemons S110AW2-100 and S110AW2-300 including all S110C-4 and S110C-5 clips, S110A2 cable managers, S110-LBL-5 designation strips, and S110-HLDR label holders or Lucent equivalent. 25 pair termination shall punch down directly to riser blocks. Coordinate with City of Tucson Telecommunications Division before terminating pairs.

2.12 PROTECTOR BLOCKS

Protector blocks shall be 188 type Multipair Protector Panel with 110 distribution system, separate splice chamber, and cover.

2.13 PROTECTORS

Protectors shall be 4B1-EW five pin protectors with Heat Coil. Protectors shall have a DC Voltage breakdown within 265-425V @ 2kV/sec, Surge Breakdown within 200-500V @ 100V/sec, and a minimum 300A (10 x 1000 µsec waveform): >50 operations

2.14 WIRE HANGERS

Wire Hangers shall be Erico CAT series with all accoutrements or equal.

2.15 LABELS

Labels shall be white metallic or Polyofelin with ¼” tall lettering computer generated.

2.16 VELCRO

Velcro is the only material permitted for bundling and securing of cable.

2.17 TELECOMMUNICATIONS GROUND BUS BAR:

- A. The Telecommunications Master Grounding Bus Bar (TMGB) shall be wall mounted 1/4"x4"x20" solid copper on 4" standoffs with insulators.
- B. The Sub System Grounding Bus Bar (SSGB) shall be Vertical rack mounted 1/8" solid copper with insulators.

2.18 CONNECTORS

- A. All copper connectors shall be Uniprise UNJ500 series style in four colors: #1 Black, #2 Ivory, #3 Gray, and #4 White. All shall be wired per T568B pinout configuration.
- B. Fiber connectors
 - 1. Workstation connectors shall be duplex SC, ceramic tip, intended for field termination. Fiber optic connectors shall be epoxy cured or hot cured. Pre-polished crimp style connectors are unacceptable.
 - 2. TC Workstation/Backbone connectors shall be of the ‘SC’ variety, ceramic tip, intended for field termination. Fiber optic connectors shall be epoxy cured or hot cured. Pre-polished crimp style connectors are unacceptable.

2.19 FIBER OPTIC SLEEVES

Fiber Optic sleeves shall be suitable for connectivity of bundled duplex, or duplex fiber jumpers.

2.20 FIBER OPTIC WARNING LABELS

Labels shall attach or affix to the Fiber cable or its path or any associated junction or pull boxes. Fiber optic warning labels shall denote the statement, "WARNING, Fiber Optic Cable" at a minimum and shall be clearly visible at a distance of 20'.

2.21 FIBER OPTIC DISTRIBUTION SHELVES

Fiber optic distribution shelves shall be for wall mounting and floor mounted racking, of an adequate size to properly terminate Backbone and all other fibers. The shelf shall include all necessary buffering/breakout, clamping, blocking and ancillary hardware to terminate all fibers. Acceptable Manufacturers are Uniprise RFE series, or Corning CCH,ADC,FL 2000 series, or approved other.

2.22 JUMPERS

- A. Jumpers shall be of the same certified transmission rating as horizontal cable for the intended circuit.
- B. Copper: Jumpers shall be yellow for IO port one, Red for IO port two, Green for IO port three and Blue for IO port four. Provide two workstation jumpers for each information outlet, one 7' and one 15' in length.
- C. Fiber: Fiber jumpers shall be duplex SC 2.0 meters in length meeting the same requirements for all other fiber cable. Provide two each duplex jumpers for each 12 strands of multi-mode backbone cable installed and two each duplex jumpers for each 6 strands on single-mode cable installed.

PART 3 – EXECUTION

3.1 TELECOMMUNICATIONS ROOMS

A. BISCI Definitions

1. Telecommunications Room (TR) is defined by BICSI as an enclosed space for housing telecommunications equipment, cable terminations, and cross-connects. This room is the recognized cross-connect between the backbone cable and horizontal cabling.
2. Horizontal Cross-connect (HC) is defined as a group of connectors, such as patch panel or punch-down block, that allows equipment and backbone cabling to be cross-connected with patch cords or jumpers.
3. Entrance Facility (EF) is defined as an entrance to a building for both public and private network service cables, including antennae, and including the entrance point at the building wall and continuing to the entrance room or space.

B. Each Telecommunications Room shall be an enclosed room dedicated to telephone and data communications equipment and termination hardware. This room shall be a minimum of ten feet by twenty feet to service up to 144 workstation drops and shall be temperature controlled to a range of 64-75 degrees F based on a 24 hr per day, 365 day per year heat load of 3000 watts. An alarm circuit shall be provided and connected to the Energy Management Control System located in the physical plant or mechanical room that activates if temperature exceeds 85 degrees F. If the facility does not have an EMCS, a mutable audible alarm must sound in a 24 hour occupied area of the building. If equipped with a local air conditioner, a dedicated circuit shall feed it.

C. At a minimum, one 20 amp dedicated electrical circuits with dedicated neutrals shall be provided as described below.

1. One quadraplex electrical outlets shall be installed in a surface mounted four inch square box at the base of each rack. In the case of wall mounted racks, the quadraplex electrical outlets shall be installed in the wall behind and below the rack. Conduit to the rack may not be routed across the floor so as to create a trip hazard or impede use of any mounting holes or equipment locations in rack.
2. Additional 20 amp quadraplex electrical outlets shall be installed in four square boxes, 18 inches center above the finished floor on the walls where needed to serve other equipment and testing equipment

D. All walls of all of the communications rooms shall be lined with 3/4" AC fire treated plywood, with the "A" side exposed. The plywood is not to be painted.

- E. At a minimum, a 12 inch ladderway shall be used to support cable above room walls and racks.
- F. Switched lighting shall be supplied and shall produce a minimum of 50 foot-candles at the rack location measured 3 foot above finished floor.
- G. Racking shall be used to house termination patch panels. Racks shall be 7 foot by 19 inch aluminum, clear finish, EIA/TIA standard floor mounted with 2 sided hole pattern. Racks shall meet 310 d standard. If wall mounting is specified, a minimum of 12 inches of bracket spacing to wall is required and bottom of rack must sit squarely on floor. All panel racks shall be SAE 12-24 screw pitch.
- H. Two Uniprise UNPMM 24P or approved equal patch panels are required for every 12 drops. The black, ivory, gray and white workstation outlets shall be terminated on the patch panels in the rack in order from lowest to highest workstation number. Each drop will be a column on the two patch panels which will be configured left to right from the patch side as follows.
 - 1. The Contractor shall terminate the **black** Uniprise UNJ500, of the station information outlet starting at the **upper leftmost position** of the **first patch panel**, and continue left to right.
 - 2. The Contractor shall terminate the **ivory** Uniprise UNJ500 of the station information outlet starting at the **lower leftmost position** of the **first patch panel**, and continue left to right.
 - 3. The Contractor shall terminate the **gray** Uniprise UNJ500 of the station information outlet starting at the **upper leftmost position** of the **second patch panel**, and continue left to right of the patch panel in identical fashion.
 - 4. The Contractor shall terminate the **White** Uniprise UNJ500 of the station information outlet starting at the **Lower leftmost position** of the **second patch panel**, and continue left to right of the patch panel in identical fashion.
 - 5. The Contractor shall supply and install one (1) wire management panel both front and back for every 12 information outlets, and not less than two panels per rack. Such wire management panels shall be of horizontal plastic rings mounted on a two and four position 19" rack panel CPI 11752-219 and CPI 11753-219 or equal. All patch panels and horizontal wire management shall be mounted consecutively, to insure that there are no gaps between panels. Vertical wire management shall be dual channel metallic CPI 11729-503 or equal, placed between all racks.

- I. Analog Voice termination shall be configured as follows.
1. At the CLEC the Contractor shall terminate the **Riser Cable** to the Riser Field of the 110AW block starting at the lower leftmost position of the block continuing left to right, and downward.
 2. The Contractor shall utilize the 110-C4 for all station field terminations **except** the 6th station position on each row. The Contractor shall utilize the 110-C5 for the 6th station position on each row.
 3. The contractor shall adhere to 100MHz cabling guideline specifying proper cable installation.
 4. The contractor shall connectorize the riser cable with a suitable RJ21 connector at the Owners end. All building riser cable shall utilize RJ21\leftrightarrowRJ21 connectivity
- J. Each Telecommunications Room, serving as a Horizontal Cross-connect, shall have a minimum of 24/24 strands of SM/MM fiber per City of Tucson Specifications between it and the Entrance Facility. A minimum 50 foot service loop shall be left at each end. Service loop shall be coiled neatly and secured with D-rings to main board observing the minimum bend radius in manufacturer's specifications.
- K. Data jacks - #1 (black), #2 (ivory), #3 (gray) #4, (white) are connected to the data punch panel serving the area and are available for data traffic up to 100 MHz.
- L. Each Telecommunications Room shall be supplied with an equipment grounding conductor meeting the requirements of NEC Article 250 and NEC Article 800.
- M. Each Telecommunications Room shall have a TMGB installed. The TMGB is typically placed 16" Above Finished Floor (AFF), below, and with direct access to the ladderway.
- N. Each Telecommunications Room shall be provided an equipment grounding conductor meeting the requirements of National Electrical Code Article 250 and 800. The equipment grounding conductor point of entry shall be local to, and terminate directly to the TMGB. The equipment grounding conductor shall be bonded to the MGBB using a 2 hole irreversible compression connector. The equipment grounding conductor shall not utilize the ladderway as a path to the TMGB.

3.2 CABLING

A. Copper

1. All workstations shall have four, four-pair Category Five extended cables with 4X0 construction. Cable, routing, support systems, and termination all must meet TIA/EIA 568B LEVEL III, TIA/EIA 569B and SRL testing requirements. All cable shall run parallel and perpendicular to the supporting steel structure. The cabling shall be supported at no more than 5 foot intervals. Cabling and support systems shall not use any part of the grid ceiling for support. When cabling traverses a part of the building framework or appurtenances, shall be supported at least 15 cm above the drop ceiling, with Category 5 J hook or other approved device. Cables shall be bundled using Velcro straps. The use of cinch type ties is unacceptable.
2. Provide two workstation jumpers for each information outlet port installed.

B. Fiber

Provide 2 strands of Multi-mode and 2 strands of Single-mode plenum Fiber Optic cable at each Conference room.

3.3 CABLE TESTING

A. All tests must be witnessed by a representative of the City of Tucson Communications Maintenance Division.

B. Test Reports

1. Contractor shall supply Test reports, in both booklet form and electronic format, showing all field tests performed to adjust each component and all field test performed to prove compliance with the specified performance criteria, upon completion of testing of the installed system.
2. Contractor shall supply one licensed copy of test equipment software which provides a means for viewing both copper and fiber test results in the format that the original test equipment was designed, suitable for running in a DOS or Windows environment.
3. Any discrepancies noted during the test shall be corrected and those tests shall be rerun.

C. Test Equipment

1. Copper

- a. Test equipment shall be suitable for certifying all EIA/TIA 568B Draft 7 250 MHz and up to 300 MHz specifications including but not limited to, power sum attenuation across pairs, attenuation, near end cross talk (NEXT), far end cross talk (FEXT) including worst-case value and frequency, wire/line mapping, split-pairs, shorts, opens, reversals, length, impedance, loop resistance, capacitance, and ambient noise spread across various frequencies and Level III compliance.
- b. Test equipment shall be a device providing for active sweep testing of Digital Signal Processing (DSP) of circuits. Contractor shall provide proof of recent factory calibration, (within the previous 12 months) of all test equipment. Copper test equipment shall be Level III+ Compliant and Draft 6 Compliant or most recent draft compliant.

2. Optical

Optical test equipment shall be suitable for measuring the attenuation and optical characteristics of the installed Fiber Optic plant. Optical test shall include but not limited to End to End attenuation via power loss; Optical Time Domain Reflectometer (OTDR), optical loss of all connectors, microbending, and conformance to optical specifications; and a power meter capable of performing end-to-end loss test on SM/MM fiber. Optical characteristic testing shall be an average of not less than 15 seconds of active measurement. Contractor shall provide proof of factory calibration within the previous 12 months of all test equipment.

D. Testing Procedures

1. Factory Certification Test: The Contractor shall supply factory reeling test, which shows compliance with all fiber cable optical, attenuation and bandwidth criteria.
2. Copper Cable Testing

All cable shall be tested and certified for all EIA/TIA 568B Draft 7 250 MHz and up to 300 MHz specifications The contractor shall test all cabling for the permanent link, as follows unless otherwise noted; riser cable between closets need only be certified to Category Three parameters. Test equipment, which certifies the cable in twenty-five pair bundles, is acceptable for use on the riser cable only.

3. Optical Fiber Testing

- a. Fiber Optic Cabling tests shall be performed on the completed end-to-end spans that include a near-end pre-connectorized single-fiber cable assembly, outside plant or riser as specified, and a far-end pre-connectorized single-fiber cable assembly. Two optical tests shall be performed as follows.
- b. The first test shall be the OTDR Test. The following acceptance tests shall be performed for each fiber greater than 100m and all backbone cable regardless in the completed cable length. Wave lengths [850], [1300], [1310], and [1550], shall be tested.
 - The OTDR tests will show any irregularities, such as discontinuities, micro-bending, Improper splices, for the cable span under test.
 - Hardcopy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results.
 - The OTDR test shall be measured in both directions.
 - A reference length of fiber, 100 m minimum, used as the delay line shall be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature.
- c. The second test shall be the Attenuation Test: End-to-end attenuation measurement shall be made on all fibers, in both directions, using a [850] [1300] [1310] [1550] nanometer light source at one end and the optical power meter in the other end. This test will be used to verify that the cable system attenuation requirements are met.
- d. The measurement method shall be in accordance with EIA 455-53A.

E. Acceptance

Acceptance of system shall occur after all required documentation, test results, certification of test results and operation by the City of Tucson, Final acceptance shall include a visual inspection of the system in its entirety and approval of City of Tucson, or their appointed representative(s).

F. Warranty

Contractor shall certify and warrant the complete system for operation at current EIA/TIA 568B 100 MHz specifications for a period of not less than 15 years.

3.4 CABLE LABELING

All horizontal fiber optic cables shall be labeled according the same scheme as horizontal cable runs described elsewhere.

All vertical or interbuilding Fiber Optic Cables will be identified with the following labeling scheme. Within 3 feet of termination, a Panduit part # PST-FO or equal yellow and black “CAUTION Fiber Optic Cable” plastic label will be attached. It will be labeled according to the following scheme:

EXAMPLE: COT-001-96MM-CHXXX-149/PWXXX-213

		Local Site Cable	Remote Site Cable
COT-	001-	96MM	CH
City of Tucson Fiber Optic Cable	Cable Number 001 to 1000 or greater	Indicates that cable contains 96 Multimode Fibers	Cable runs between CH= City Hall Basement Room #149 and PW = Public Works Room #213

- | | |
|----------------------------|-----------------------|
| OSP = Outside Plant Cable | SM = Singlemode |
| 3 DFX = Multimode Outside | HY = Hybrid |
| 4 DNX = Singlemode Outside | 0 = Basement |
| OFNR = Riser Cable Indoor | 1 = First floor |
| OFNP = Plenum Cable Indoor | 2 = Second floor |
| MM = multimode | 3 = Third floor, etc. |

3.5 CONDUITS – ABOVE GRADE

- A. All conduits shall be routed parallel or perpendicular to the building lines. No diagonal runs will be permitted.
- B. All raceway shall be painted to match its environs. All 90-degree turns in raceway must be provided with the appropriate junction to ensure non-violation of bend radius.
- C. Any conduit from a workstation that does not go home-run to the telecommunications room but rather is specified as a stub out above a push-up tile ceiling shall include a gentle sweep toward the proposed telecommunications closet, a connector, and bushing.
- D. Where conduits are not continuous from workstation to closet, cables must be supported in an approved method every 5 feet.
- E. All raceways and conduits passing through fire barriers shall be filled in accordance with all local codes. Fire proofing shall at a minimum be rated for one (1) hour.

3.6 UNDERGROUND CONDUIT SYSTEM

3.6.1 Conduit.

- A. **Handling and Storage.** All conduit shall be transported in modules or bundled in a straight and level position. The straps securing the conduit to any transport vehicle shall be a minimum of 4 inches in width and shall not deform or damage the conduit in any manner. Conduits shall be unloaded in accordance with the manufacturer's recommendations and shall not be dropped to the ground.

Conduits shall be stored in a straight and level position in stacks not exceeding 8 feet in height. Materials shall be stored in an approved manner and covered to prevent ultraviolet deterioration due to the exposure to sunlight. When stored, conduit ends shall not be capped nor shall conduit be subject to temperatures in excess of 140° F.

- B. **Cleaning.** The interior of the conduit shall be kept clean and free of debris. Prior to installation, all foreign materials shall be removed from the interior of the conduit with compressed air and a swab.
- C. **Size.** Unless otherwise indicated on the plans or special provisions, all conduit shall be 4-inch diameter.
- D. **Cuts and Connections.** The conduit shall be cut square, de-burred, and trimmed to remove all rough edges. PVC conduit connections shall be of the solvent weld type. Wipe conduit dry and clean before joining. Apply a full coat of primer to the pipe and coupling per the manufacturer's recommendations. Apply a full and even coat of solvent cement to the entire area inserted into the fitting. Prevent excess cement from accumulating in the interior of the conduit. Allow joint to cure a minimum of 20 minutes. The complete joint shall be water tight. Where a connection is made to a steel bend, the coupling used shall be a threaded PVC female adapter.

Expansion fittings shall not be installed in PVC conduit runs except as follows. Expansion fittings shall be installed in conduit runs where both ends are fixed in-place, such as between two foundations, and within concrete structures. Expansion fittings shall allow for a minimum linear expansion of six inches.

- E. **Bends.** Bends shall be installed only when absolutely necessary. All bends shall be constructed of rigid steel conduit. Bends shall be factory bent or field bent. Bends shall have a radius of not less than 12 times the nominal diameter of the conduit. Conduit shall be bent without crimping or flattening, using the longest radius practicable. The sum of the deflection angles of all bends in any conduit run shall not exceed 270 degrees between termination and/or junction points. For the purpose of calculating the sum of the deflection angles, bends with a radius of 500 feet or greater may be excluded from this criteria.
- F. **End Treatment.** Conduit ends shall be capped with conduit end caps at all times when work is not in progress. Rigid steel sweeps terminating in pull boxes shall be plugged.
- G. **Placement.** Conduit runs shown on the plans shall be changed only to avoid underground obstructions and only as directed by the Engineer and City of Tucson Communications Engineering (CE) Representative.

Unless otherwise specified, conduits shall be placed with a minimum cover of 36 inches to the top of the conduit below the finished grade. All conduit runs on under roadways or parking lots on City property shall be encased in concrete. Additionally, the conduit shall be placed to provide a minimum of 24 inches of clearance between the bottom of all subgrade scarification and the top of the conduit.

Conduits shall be installed along the straightest horizontal and vertical alignment practicable, and with a uniform depth of cover. Variations in the alignment shall be accomplished with smooth transitions maximizing the radius of the bends. In cases where it is impossible to maintain the alignment of the conduit, the grade of the conduit shall be transitioned using the minimum number and the longest radius bends. Should discovered field conditions necessitate additional bends in the conduit run, the location and number of pull boxes shall be adjusted as directed by the Engineer and City of Tucson Communications Engineering (CE) Representative.

Conduits encased in concrete shall be installed on plastic conduit spacers. The spacers shall be placed at suitable locations to prevent sagging of the conduit between spacers or at 10 foot maximum centers. Prior to the placement of the concrete, the conduits shall be tied down to prevent them from floating.

Conduit penetrations into pull boxes shall be made using the knockouts or shall be cored in the structure. Conduits entering through the side wall of pull boxes shall be located three inches above the floor and three inches away from the end wall of the box. Conduit entering the bottom of pull boxes shall be located in the near side corner of the box, approximately 3 inches away from the side and end walls. The conduit shall be sloped towards the top center of the box to facilitate pulling of the cables and innerduct. Conduits terminating in pull boxes shall terminate a minimum of three inches inside the box wall. The void between the conduit and the box shall be completely filled with mastic to form a watertight seal.

Conduits entering vaults shall enter through single duct knockouts. The location of the knockout shall be as indicated on the plans, or directed by the Engineer. The joint between the knockout and the conduit shall be filled to form a watertight seal.

At all locations where the conduits cross under a new curb, the letters "FO" shall be cut into the top of the curb directly over the conduit run. The letters shall be three inches tall and shall be clearly defined.

3.6.2 Trenching.

- A. Unless otherwise specified, all conduit runs shall be installed by trenching methods. Trenching shall include the removal of all material to the design grade no matter what type of material is encountered. The alignment of the conduit shall be staked in the field per the City of Tucson's standard procedures.
- B. When trenching in excess of five feet is required, the contractor shall submit, in writing to the Engineer and City of Tucson Communications Engineering (CE) Representative, a detailed description of the proposed trenching operations, including shoring methods, prior to the commencement of construction.
- C. All conduit shall be covered with bedding material at the completion of each day's work to prevent shrinkage and thermal expansion that could influence the alignment of the conduit.
- D. Concrete encasement shall be a minimum of Class B (2,500 PSI) in accordance with Pima County/City of Tucson Standard Specifications and provide a minimum cover on all sides of the conduit of 3 inches. Otherwise, bedding and shading of the conduit shall be in accordance with the plans and specifications of the subject project. When installed adjacent to water mains, the conduit shall be encased in Controlled Low Strength Material (CLSM).

3.6.3 Backfill.

- A. Upon completion of the conduit and bedding installation, the trench shall be backfilled and compacted. The backfill shall be constructed according to the Pima County, City of Tucson, Standard Specifications and Details for Public Improvements.
- B. Place the detectable warning tape in the backfill, 18 inches above the top of the conduit.
- C. All underground conduits shall be buried a minimum of 36 inches cover.
- D. When the conduit is installed in a joint trench with a water main, the bedding and shading material shall be aggregate bedding material meeting the specifications for the water main.

3.6.4 Boring and Jacking.

- A. The boring and jacking method shall be approved by the engineer prior to the commencement of work. Where a conduit run is required by the plans to be installed by boring or jacking, the trenching method shall not be utilized except with prior written approval of the Engineer.
- B. When casing is used, the casing shall be schedule 40 “standard wall” steel pipe. The casing shall not deviate more than 0.20 feet from the design grade. The joints in the casing shall be fully welded in accordance with A.S.M.E. Section 9. Concrete end seals shall be provided at each end. The intervening annular space shall be filled with sand material approved by the Engineer.
- C. Boring and jacking pits shall be located a minimum of two feet outside the pavement edge. The diameter of the bore shall be as close to the outside diameter of the conduit such that it will enable the conduit to be installed. At all locations where the diameter of the bore is 2 inches, or greater, than the outside diameter of the conduit, the interstitial space between the conduit and the bore shall be filled with slurry. All boring and jacking methods used shall neither damage nor deform the conduit. The installed conduit shall conform with the alignment and grade shown on the plans.

3.6.5 Installation in Concrete Structures. Conduit embedded in concrete structures shall be securely attached to the reinforcing steel at locations and intervals detailed on the plans. Expansion fittings shall be installed at all locations where the conduit crosses expansion joints in the structure. Expansion joints shall also be installed at the point where the conduit enters and exits the concrete structure. Where it is not possible to install expansion joints, the conduit shall be installed in a conduit sleeve of sufficient size to provide a minimum of 1/2-inch clearance between the outside diameter of the conduit and the inside wall of the sleeve. Sleeves shall be discontinuous across the expansion joints in the structure.

3.6.6 Pull Boxes and Vaults. Prior to setting the pull box or vault, verify that the excavation is to the design elevation and alignment. Pull boxes shall be placed on a minimum of five cubic feet of clean 1” (size #57) crushed stone to provide drainage. Vaults shall be placed on a minimum of 16 cubic feet of clean 1” (size #57) crushed stone with a minimum 8” sump hole knocked out to provide drainage. Pull boxes and vaults shall be placed such that the crushed stone does not wash away or into the conduit. Vaults and pull boxes shall NOT be placed in a location of water drainage or standing water. The top plane of the cover shall be a minimum of 6” above possible standing water level for the location. Install the precast sections in accordance with ASTM C891. Joints between the precast sections shall be sealed with a flexible butyl sealant meeting the requirements of AASHTO M-198. Set boxes and vaults true and plumb. Install precast adjustment rings and the frame and cover to finished grade. Backfill and compact around the structure avoiding damage to the structure. The backfill shall be compacted to a minimum of 95 percent of the maximum density as determined by ASTM D698.

Pull boxes shall be encased in a concrete ring a minimum 10” wide and a minimum of 12” deep on compacted soil. Each pullbox/vault shall be provided with a 5/8” by eight foot ground rod and acorn, driven vertically in the corner with six inches of rod exposed above the top of the drainage rock. Cables passing through pull boxes require a minimum 50 feet service loop where attainable without exceeding manufacturer’s minimum bend radius. Cables pulled through manholes/ vaults require not less than 150 feet before exiting.

3.6.7 Innerducts. All 4 inch conduits shall have 4 (quantity) 1 inch *smoothwall exterior ribbed interior* innerducts with 1250 pound test rated pull strength mule tape installed.

3.6.8 Tracer Wire, Electronic Marker, Mule Tape. A continuous, separate #10 AWG THW/XHHW CU green insulated tracer wire shall be installed in each conduit run, external to the innerducts. All lubricants used in the pulling of the tracer wire shall be water soluble. No splicing of the tracer wire shall be permitted in the conduit runs. The ends of the wire shall extend into each pull box, or vault, a minimum of 5 feet, coiled and secured. Connect the ends of all tracer wires within a pull box, or vault, together to a common lug. An electronic marker, 3M model 1255 mini-marker shall be placed by the Contractor at the location of any capped conduit not in a building or pullbox. All unoccupied or capped conduits shall have a detectable 2500 pound test rated pull strength mule tape installed, secured at each end and shall be labeled with location of opposite end.

3.6.9 Building Penetrations. Building penetrations shall be stubbed up 6 inches from finished grade and capped. Seal all penetrations to the same specification as the original.

3.6.10 Pole Risers. All risers off power poles shall consist of 4” Intermediate Metallic Conduit (IMC) Riser with (4) 1” Innerducts, Watertight Alibi, and Blank Duct Plugs. Installed per TEP Electric Service Requirements for Riser Details – Telco/CATV/CAP, SR-221 or per most current Revision.

3.6.11 Underground Conduit Testing and Cleaning.

A. The completed conduit runs shall be cleaned and tested prior to final acceptance. Cleaning shall consist of pulling a swab through the conduit and removing all foreign material from within the conduit. If water is allowed to enter the conduit during construction, it shall be blown out or removed by other satisfactory means prior to the acceptance of the system. Vaults and pull boxes shall be cleaned of all debris. Upon completion of the cleaning operations, the ends of the conduit shall be capped.

- B. All conduit runs shall be clearance tested after the completion of all backfilling and subgrade preparation operations. This test shall consist of pulling a mandrel through the conduit run. The mandrel shall be segmented with an outer diameter not less than 1/4 inch smaller than the inside diameter of the conduit, and shall be minimum 10" inches in length. The test shall be considered acceptable when the mandrel can be passed through the entire conduit run with a pulling force of 300 pounds or less. Each conduit run shall be verified for continuity along its entire length, as noted on the plans, and by means of an underground line locator. The installed conduit system shall be marked on the ground using standard bluestake color code and markings procedures.
- C. All modifications, testing and final inspection of the system shall be scheduled with, and conducted in the presence of the Communications Engineering (CE) Division of the City of Tucson Department of Information Technology Representative. Provide 72 hour advance notice to Bobby Sweet at 419-3459. The field inspector shall notify CE of the construction schedule to facilitate inspection of the City fiber conduits. All portions of the system that do not pass the specified testing shall be repaired by the contractor, and retested, at no additional cost.

3.6.12 Building Penetrations. All building penetrations shall be reviewed and approved by Communications Engineering (CE) Division of the City of Tucson Department of Information Technology Representative. Penetrations shall be cored unless otherwise approved by CE representative. All penetrations shall be executed and sealed per local, state, and federal fire codes.

3.6.13 As-Built Drawings. At the completion of the project, one electronic and one reproducible vellum copy of the "As-Built" drawings and shall be provided to the CE Division of the City of Tucson Department of Information Technology.

Section 975 - Telecommunications Infrastructure: DOT Format

975-1 DESCRIPTION

The work covered under this section shall consist of a Complete-in-Place installation, furnishing all material, labor and equipment, and installing conduit, pull boxes, vaults, and tracer wires for an underground fiber optic conduit system, including excavation, backfilling, compacting, jacking, and boring in accordance with the details.

975-2 MATERIALS

975-2.01 Polyvinyl Chloride (PVC) Conduit. All conduit shall be listed by UL and conform to NEC standards. Unless otherwise specified, all conduit to be installed underground or installed in concrete structures shall be 4-inch diameter, rigid Polyvinyl Chloride (PVC) Non-Metallic Conduit. The PVC conduit shall be schedule 40, heavy wall, sunlight resistant, manufactured from high impact material and shall be rated for use at 90 degrees centigrade. The conduit shall meet the specifications of UL 651 and NEMA TC-2, and furnished with interface fit bell ends. Fittings shall be schedule 40 PVC, meeting the specifications of NEMA TC-3 and UL 514.

975-2.02 Conduit with Integral Innerduct. Conduit with Integral Innerduct shall be of schedule 40 PVC in modular, slip fit lengths. Shall have pre-lubricated innerducts with internal spacers and which expand and contract at the same rate as the outerduct. Shall have anti-reversing gaskets, and an o-ring gasket at bell base. Shall have inward tapering holes on coupling body for easy assignment, printed indication such as "Install Print Side Up" to keep system straight during installation, and marked innerduct and marked hole on coupling body to insure proper innerduct alignment and allow crews to work from opposite directions. Bends shall be flexible and engineered to be cut-through resistant. Carlon Telecom Systems Multi-Gard or equivalent. All integral innerducts shall have a continuous non-spliced, unknotted detectable 1250 pound test mule tape installed.

975-2.03 Solvent Cement for Polyvinyl Chloride (PVC) Conduit and Couplings. All solvent cement shall meet the requirements of ASTM D 2564. The cement shall be of a medium or heavy bodied cement capable of making watertight joints. The cement and primer shall be of a type recommended by the manufacturer of the conduit.

975-2.04 Rigid Steel Conduit Sweeps. Conduit sweeps shall be listed by UL and conform to NEC standards. The sweeps shall be steel, hot dipped zinc coated, meeting the requirements of UL 6 and ANSI C80.1, and shall carry the Underwriters Laboratory label. Non-thread couplings shall not be used. Sweeps shall have a minimum radius of 12 times the nominal diameter of the conduit. Steel conduit sweeps shall have a factory applied 40 mil PVC coating or be doubled (half overlap) wrapped with a 10 mil PVC plastic tape specifically manufactured for corrosion protection of metallic conduits installed below grade.

975-2.05 Flexible Conduit. When specifically indicated on the plans and where approved by the engineer, flexible solid wall direct bury conduit may be used. The conduit shall be manufactured of Polyvinyl Chloride (PVC), or Polyethylene (PE) plastic. The conduit shall be specifically manufactured for direct buried fiber optic raceway systems and shall be Carlon “Optic-Gard PE” conduit, or approved equal. Flexible conduit shall not be utilized for making bends in conduit system. Connection between the flexible conduit and conduits of other materials shall be made with a watertight transition coupling manufactured for the specific type of material.

975-2.06 Plastic Conduit Spacers. Spacers shall be constructed of Polyvinyl Chloride (PVC) or other non-metallic material. The spacers shall be vertical and horizontal interlocking and provide a minimum of 3-inch clearance between conduits. Base spacers shall be provided with a wide base plate to provide solid support on the bottom of the trench. The base spacers shall provide for a minimum clearance of 3 inches between the bottom of the trench and the conduit.

975-2.07 Aggregate Bedding Material. Aggregate material for bedding material shall meet the gradation indicated in the specifications and on the drawings for the subject project. The plasticity index shall also conform to the specifications under which the subject project is designed and constructed.

975-2.08 Controlled Low Strength Material (CLSM). Materials comprising the controlled strength material shall conform to the requirements of Section 1006. CLSM mix designs shall be in accordance with Table 975-2. Unless otherwise designated on the plans, in the special provisions or directed by the Engineer, the CLSM shall be Mix No. 2.

Table 975-2

Mix Proportions For Controlled Low Strength Material

	<u>CLSM No. 1</u>	<u>CLSM No. 2</u>	<u>CLSM No. 3</u>
Compressive Strength, 28 days PSI	50	500	1000
Portland Cement (lb)	60	190	280
Water (lb)	475	460	440
Fly Ash (lb)	290	300	300
Fine Aggregate (lb)	2,770	2,680	2,650

975-2.09 Detectable Warning Tape. On open trenching an electronically detectable 6” Fiber Warning tape shall be installed 18” above the conduit. Tape shall be acid and alkali-resistant polyethylene film, with a minimum thickness of 0.004 inch. The tape shall have a minimum strength of 7500 PSI lengthwise and 1,500 PSI crosswise. The tape shall be manufactured with integral wires, foil backing, or other means to enable its detection by a metal detector when the tape is buried up to a depth of 3 feet deep. The tape shall be orange in color and have the following continuous inscription, “CAUTION - FIBER OPTIC CABLE BURIED BELOW”. The inscription shall be 2 inch black letters.

975-2.10 Backfill Material. The backfill material shall conform to that of the subject project.

975-2.11 Tracer Wire. The cable and wire shall be listed by UL and conform to NEC standards. The wire shall be a continuous unspliced stranded CU 10AWG, rated for 600 volts, and shall be type THW or XHHW. The color of the wire shall be green. The wire shall be of the required length to eliminate all splices within the conduit.

975-2.12 Pull Boxes. Communications pull boxes shall be UL listed. Pull boxes shall be of a reinforced composite material of a neutral color. The pullbox shall have a bolt-down cover secured by a minimum of two (2) recessed hex-head bolts. The pullbox cover shall have the word “COMMUNICATIONS” in permanent raised, stamped or welded lettering. The pullbox cover shall have a skid-resistant surface. Pull boxes shall be open base. The pullbox cover shall have two (2) ½” x 4” pull slots. The pullbox base shall have two (2) 4 ½” x 4 1/2” mouse holes, one at each end. Pull boxes may be extended by means of an “extension”. The extension shall have eight (8) 4 1/2” x 4 1/2” knockouts, two on each side. Contractor shall provide all necessary collars, extensions, hardware, sealant, and conduit caps. All conduit entrances shall be sealed. The assigned pullbox number shall be painted on the box at the time of installation. Chipped, cracked, or otherwise damaged boxes and covers will not be accepted.

975-2.13 Vaults. Communications vaults shall be UL listed. Vault base shall be pre-cast concrete with a minimum thickness of 4”. Vault cover shall be pre-cast concrete with a minimum 36” x 36” galvanized steel locking lid secured by a minimum of one (1) recessed hex-head bolt. The cover lid shall have “COMMUNICATIONS” written on it in permanent raised, stamped or welded lettering. The vault base and vault cover shall be gasketed and weather proof. Vaults shall have a minimum outside dimension of 48” long by 48” wide by 50” high with a minimum thickness of 4”. The base shall have one (1) 8” diameter by 4” deep sump hole knockout in the floor. The base interior shall have a minimum of one (1) 2 ½” diameter ground rod knockout in the floor, at a corner; the base interior shall have four (4) 7/8” diameter pulling irons, one centered on each side. The base exterior walls shall have four (4) 36” “C” channels precast in the sides, one on each side; the base exterior shall have four (4) 18” x 18” knockouts, one on each side; and, the base exterior shall have sixteen (16) 4 1/2” diameter knockouts for 4” conduit entrances, four on each side. Contractor shall provide all necessary collars, extensions, hardware, sealant, and conduit caps. All conduit entrances shall be sealed. The assigned box number shall be painted on the box at the time of installation. Chipped, cracked, or otherwise damaged boxes and covers will not be accepted.

975-2.14 Portland Cement Concrete. Concrete shall be Class B meeting the requirements of Section 1006 of the Pima County/City of Tucson Standard Specifications for Public Improvements.

975-2.15 Innerduct. Innerduct shall be 1" PVC constructed of a smooth walled exterior and a ribbed interior with a continuous unknotted 1250 pound test muletape installed. No corrugated innerduct will be accepted.

975-2.16 Watertight Alibi. Watertight Alibi shall consist of a Quadraplex Duct Plug designed to seal around, organize, and support innerduct where it emerges at the top of the risers, pull boxes, and vaults. Fasteners shall be stainless steel. Plug shall support a minimum of 400 lbs of cable, and shall be removable. Jackmoon or equivalent. No chemical seals will be accepted.

975-2.17 Blank Duct Plugs. Blank Duct Plugs shall be installed in each individual innerduct where it emerges at the top of the risers, pull boxes, and vaults. Shall be all plastic construction, corrosion proof, water and air tight to 30 psi. Jackmoon or equivalent.

975-3 CONSTRUCTION DETAILS

975-3.01 Conduit.

(A) **Handling and Storage.** All conduit shall be transported in modules or bundled in a straight and level position. The straps securing the conduit to the vehicle shall be a minimum of 4 inches in width and shall not deform or damage the conduit in any manor. Conduits shall be unloaded in accordance with the manufacturer's recommendations and shall not be dropped to the ground.

Conduits shall be stored in a straight and level position in stacks not exceeding 8 feet in height. Materials shall be stored in an approved manner and covered to prevent ultraviolet deterioration due to the exposure to sunlight. When stored, conduit ends shall not be capped nor shall conduit be subject to temperatures in excess of 140° F.

(B) **Cleaning.** The interior of the conduit shall be kept clean and free of debris. Prior to installation, all foreign materials shall be removed from the interior of the conduit with compressed air and a swab.

(C) **Size.** Unless otherwise indicated on the plans or special provisions, all conduit shall be 4-inch diameter.

(D) Cuts and Connections. The conduit shall be cut square, de-burred, and trimmed to remove all rough edges.

PVC conduit connections shall be of the solvent weld type. Wipe conduit dry and clean before joining. Apply a full coat of primer to the pipe and coupling per the manufacturer's recommendations. Apply a full and even coat of solvent cement to the entire area inserted into the fitting. Prevent excess cement from accumulating in the interior of the conduit. Allow joint to cure a minimum of 20 minutes. The complete joint shall be water tight. Where a connection is made to a steel bend, the coupling used shall be a PVC female adapter.

Expansion fittings shall not be installed in PVC conduit runs unless otherwise specified. Expansion fittings shall be installed in conduit runs where both ends are fixed in-place, such as between two foundations, and within concrete structures. Expansion fittings shall allow for a minimum linear expansion of six inches.

(E) Bends. Bends shall be installed only when absolutely necessary. All bends shall be constructed of rigid steel conduit. Bend shall be factory bent or field bent. Bends shall have a radius of not less than 12 times the nominal diameter of the conduit. Conduit shall be bent without crimping or flattening, using the longest radius practicable. The sum of the deflection angles of all bends in any conduit run shall not exceed 270 degrees between termination and/or junction points. For the purpose of calculating the sum of the deflection angles, bends with a radius of 500 feet or greater may be excluded from this criteria.

(F) End Treatment. Conduit ends shall be capped with conduit end caps at all times when work is not in progress. Rigid steel sweeps terminating in pull boxes shall terminate with an approved plastic bushing.

(G) Placement. Conduit runs shown on the plans shall be changed only to avoid underground obstructions and only as directed by the Engineer and TRP Representative.

Unless otherwise specified, conduits shall be placed with a minimum cover of 36 inches to the top of the conduit below the finished grade; the minimum requirement for Transportation projects is 30" due to the depth of electrical conduit placement. When conduit runs, or any part thereof, cannot be installed at the minimum depth, the run, or part thereof, shall be encased in concrete.

Conduits shall be installed along the straightest horizontal and vertical alignment practicable, and with a uniform depth of cover. Variations in the alignment shall be accomplished with smooth transitions maximizing the radius of the bends. In cases where it is impossible to maintain the alignment of the conduit, the grade of the conduit shall be transitioned using the minimum number and the longest radius bends. Should discovered field conditions necessitate additional bends in the conduit run, the location and number of pull boxes shall be adjusted as directed by the Engineer and City of Tucson Communications Engineering (CE) Representative.

Conduits to be encased within Controlled Low Strength Material (CLSM) or concrete shall be installed on plastic conduit spacers. The spacers shall be placed at suitable locations to prevent sagging of the conduit between spacers or at 10 foot maximum centers. Prior to the placement of the CLSM or concrete, the conduits shall be tied down to prevent them from floating.

Conduit penetrations into pull boxes shall be made using the knockouts or shall be cored in the structure. Conduits entering through the side wall of pull boxes shall be located three inches above the floor and three inches away from the end wall of the box. Conduit entering the bottom of pull boxes shall be located in the near side corner of the box, approximately 3 inches away from the side and end walls. The conduit shall be sloped towards the top center of the box to facilitate pulling of the cables and innerduct. Conduits terminating in pull boxes shall terminate a minimum of three inches inside the box wall. The void between the conduit and the box shall be completely filled with mastic to form a watertight seal.

Conduits entering vaults shall enter through single duct knockouts. The location of the knockout shall be as indicated on the plans, or directed by the Engineer. The joint between the knockout and the conduit shall be filled to form a watertight seal.

At all locations where the conduits cross under a new curb, the letters "FO" shall be cut into the top of the curb directly over the conduit run. The letters shall be three inches tall and shall be clearly defined.

975-3.02 Trenching. Unless otherwise specified, all conduit runs shall be installed by trenching methods. Trenching shall include the removal of all material to the design grade no matter what type of material is encountered. The alignment of the conduit shall be staked in the field per the City of Tucson's standard procedures.

When trenching in excess of five feet is required, the contractor shall submit, in writing to the Engineer, a detailed description of their proposed trenching operations, including shoring methods, prior to the commencement of construction.

All conduit shall be covered with bedding material or Controlled Low Strength Material (CLSM) at the completion of each day's work to prevent shrinkage and thermal expansion that could influence the alignment of the conduit.

Concrete encasement shall be a minimum of Class B (2,500 PSI) in accordance with Pima County/City of Tucson Standard Specifications and provide a minimum cover on all sides of the conduit of 3 inches. Otherwise, bedding and shading of the conduit shall be in accordance with the plans and specifications of the subject project. When installed adjacent to water mains, the conduit shall be encased in Controlled Low Strength Material (CLSM).

(A) Bedding and Shading. Bedding and shading of the conduit shall be in accordance with the following:

Conduits installed in conjunction with Tucson Water projects shall be designed and installed under the plans and specifications of the subject project.

Conduits installed with traffic signal or street lighting conduits shall be designed and installed under the plans and specifications of the subject project.

Conduits with a depth of cover less than cited above, and where indicated on the plans, shall be encased in concrete. The concrete shall be placed to provide a minimum of three inches of encasement on all sides of the conduit.

(B) Backfill. Upon completion of the conduit and bedding installation, the trench shall be backfilled and compacted. The backfill shall be designed and constructed under the plans and specifications of the subject project. Place the detectable warning tape in the backfill, 18 inches below finished grade and directly above the conduit.

975-3.03 Boring and Jacking. Conduit runs shall be installed by boring and jacking methods when required by the plans or directed by the engineer. The boring and jacking method shall be approved by the engineer prior to the commencement of work. Where a conduit run is required by the plans to be installed by boring or jacking, the trenching method shall not be utilized except with prior written approval of the Engineer.

When casing is used, the casing shall be schedule 40 "standard wall" steel pipe. The casing shall not deviate more than 0.20 feet from the design grade. The joints in the casing shall be fully welded in accordance with A.S.M.E. Section 9. Concrete end seals shall be provided at each end. The intervening annular space shall be filled with sand material approved by the Engineer.

Conduits installed within the casing used for water mains shall consist of either four each one (1) inch, four each one and one-half (1 1/2) inch, or two, or more, two (2) inch diameter flexible conduits. The largest practical size shall be used. The conduits shall be strapped to the glass reinforced skids installed on the water line, pulled into the casing after the water main is installed, or installed on a hanger welded to the casing. The alignment of the conduits shall be maintained as straight as possible. The placement of sand within the annular space of the casing shall be controlled to a rate that does not displace the conduit.

Boring and jacking pits shall be located a minimum of two feet outside the pavement edge. The diameter of the bore shall be as close to the outside diameter of the conduit such that it will enable the conduit to be installed. At all locations where the diameter of the bore is 2 inches, or greater, than the outside diameter of the conduit, the interstitial space between the conduit and the bore shall be filled with slurry. All boring and jacking methods used shall neither damage nor deform the conduit. The installed conduit shall conform with the alignment and grade shown on the plans.

975-3.04 Concrete Structures. Conduit embedded in concrete structures shall be securely attached to the reinforcing steel at locations and intervals detailed on the plans. Expansion fittings shall be installed at all locations where the conduit crosses expansion joints in the structure. Expansion joints shall also be installed at the point where the conduit enters and exits the concrete structure. Where it is not possible to install expansion joints, the conduit shall be installed in a conduit sleeve of sufficient size to provide a minimum of 1/2-inch clearance between the outside diameter of the conduit and the inside wall of the sleeve. Sleeves shall be discontinuous across the expansion joints in the structure.

975-3.05 Pull Boxes and Vaults. Prior to setting the pull box or vault, verify that the excavation is to the design elevation and alignment. Pull boxes shall be placed on a minimum of five cubic feet of clean 1" (size #57) crushed stone to provide drainage. Vaults shall be placed on a minimum of 16 cubic feet of clean 1" (size #57) crushed stone with a minimum 8" sump hole knocked out to provide drainage. Pull boxes and vaults shall be placed such that the crushed stone does not wash away or into the conduit. Vaults and pull boxes shall NOT be placed in a location of water drainage or standing water. Set boxes and vaults true and plumb. The top plane of the cover shall be a minimum of one inch above finished grade and six inches above possible standing water level for the location. Backfill and compact around the structure avoiding damage to the structure. The backfill shall be compacted to a minimum of 95 percent of the maximum density as determined by ASTM D698.

Pull boxes shall be encased in a concrete ring a minimum 10" wide and a minimum of 12" deep on compacted soil. Each pullbox/vault shall be provided with a 5/8" by eight foot ground rod and acorn, driven vertically in the corner with six inches of rod exposed above the top of the drainage rock.

Install precast sections in accordance with ASTM C891. Joints between the precast sections shall be sealed with a flexible butyl sealant meeting the requirements of AASHTO M-198. Install precast adjustment rings and the frame and cover to finished grade.

Cables passing through pull boxes require a minimum 50 feet service loop where attainable without exceeding manufacturer's minimum bend radius. Cables pulled through manholes/vaults require not less than 150 feet before exiting.

975-3.06 Innerducts. All 4 inch conduits shall have 4 (quantity) 1 inch *smoothwall exterior ribbed interior* innerducts with 1250 pound test rated pull strength mule tape installed.

975-3.07 Tracer Wire, Electronic Marker, Mule Tape. A continuous, separate #10 AWG THW/XHHW CU insulated tracer wire shall be installed in each conduit run, external to the innerducts. All lubricants used in the pulling of the tracer wire shall be water soluble. No splicing of the tracer wire shall be permitted in the conduit runs. The ends of the wire shall extend into each pull box, or vault, a minimum of 5 feet, coiled and secured. Connect the ends of all tracer wires within a pull box, or vault, together to a common lug. An electronic marker, 3M model 1255 mini-marker shall be placed by the Contractor at the location of any capped conduit not in a building or pullbox/vault. All unoccupied or capped conduits shall have a continuous unspliced unknotted 2500 pound test rated 22AWG detectable mule tape installed, secured at each end and shall be labeled with location of opposite end.

975-3.08 Testing and Cleaning. The completed conduit runs shall be cleaned and tested prior to final acceptance. Cleaning shall consist of pulling a swab through the conduit and removing all foreign material from within the conduit. If water is allowed to enter the conduit during construction, it shall be blown out or removed by other satisfactory means prior to the acceptance of the system. Vaults and pull boxes shall be cleaned of all debris. Upon completion of the cleaning operations, the ends of the conduit shall be capped. RGS sweeps terminating in pull boxes shall be plugged.

All conduit runs shall be clearance tested after the completion of all backfilling and subgrade preparation operations. This test shall consist of pulling a mandrel through the conduit run. The mandrel be segmented with an outer diameter of 1/4 inch less than the inside diameter of the conduit, and shall be minimum 10" inches in length. The test shall be considered acceptable when the mandrel can be passed through the entire conduit run with a pulling force of 300 pounds or less. Each conduit run shall be verified for continuity along its entire length, as noted on the plans, and by means of an underground line locator. The installed conduit system shall be marked on the ground using standard bluestake color code and markings procedures.

All testing of the system shall be scheduled with, and conducted in the presence of the Engineer. All modifications, testing and final inspection of the system shall be scheduled with, and conducted in the presence of the Communications Engineering (CE) Division of the City of Tucson Department of Information Technology Representative. Provide 72 hour advance notice to Bobby Sweet at 419-3459. The field inspector shall notify the Communications Engineering of the construction schedule to facilitate inspection of the City fiber conduits. All portions of the system that does not pass the specified testing shall be Operations repaired by the contractor, and retested, at no additional cost.

975-4 METHOD OF MEASUREMENT

975-4.01 Conduits. Conduits shall be measured by the linear foot for each diameter size of conduit. The measurement shall be from center to center of pull box or vault. No measurement or direct payment will be made for the trenching, bedding, encasement, tracer wire, marking tape, mule tape, backfill and testing, the cost being considered as included in the contract price for the conduit.

975-4.02 Pull Boxes. Pull boxes will be measured as a unit for each pull box installed complete with cover and accessories.

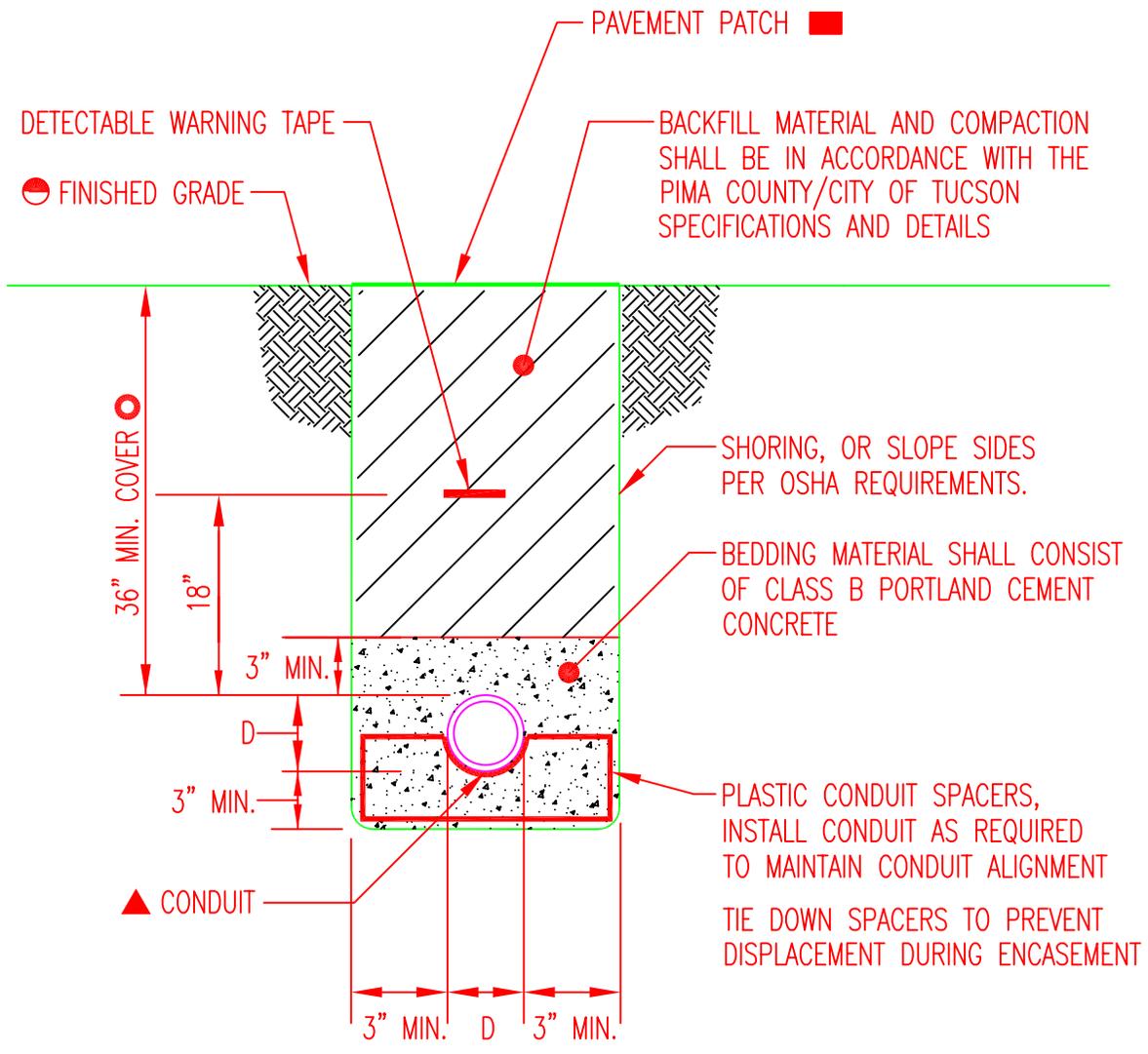
975-4.03 Vaults. Vaults will be measured as a unit for each vault complete with frame and cover and accessories.

975-5 BASIS OF PAYMENT

975-5.01 Conduit. Acceptable quantities of conduit, measured as provided above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for the work, complete in place, including any excavation, removals of obstruction, bedding, encasement, backfill, and any incidentals necessary to complete the work.

975-5.02 Pull Boxes. Acceptable quantities of pull boxes, measured as provided above, will be paid for at the contract unit price each, which price shall be full compensation for the work, complete in place, including any excavation, removals of obstruction, bedding, coring, knockouts, backfill, and any incidentals necessary to complete the work.

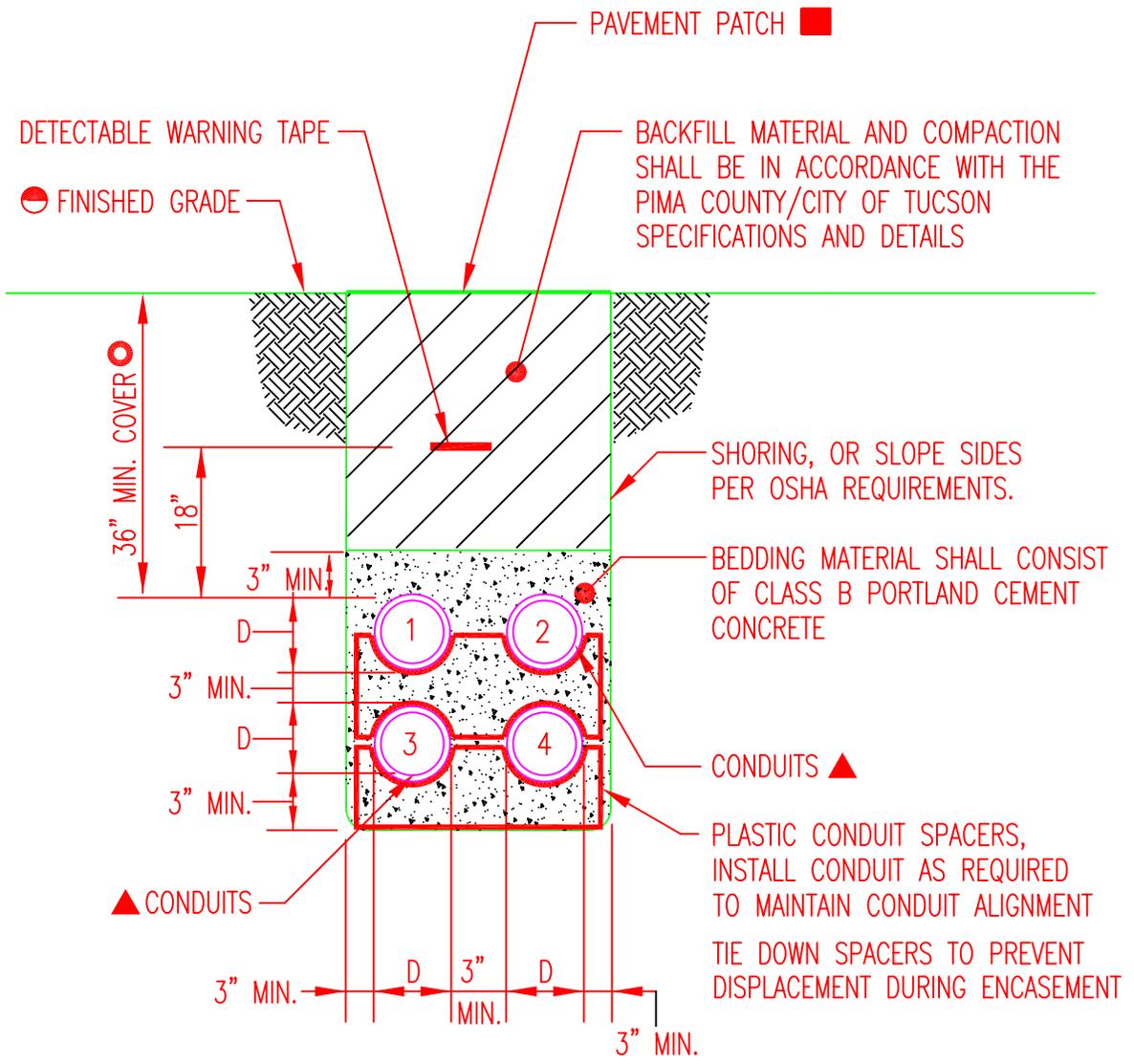
975-5.03 Vaults. Acceptable quantities of vaults, measured as provided above, will be paid for at the contract unit price each, which price shall be full compensation for the work, complete in place, including any excavation, removals of obstruction, coring, knockouts, support channels, bedding, backfill, risers, frames and covers, accessories, and any incidentals necessary to complete the work.



TYPE 1: SINGLE FO CONDUIT

REFER TO SHEET 6 OF 6 FOR GENERAL NOTES AND SYMBOLS.

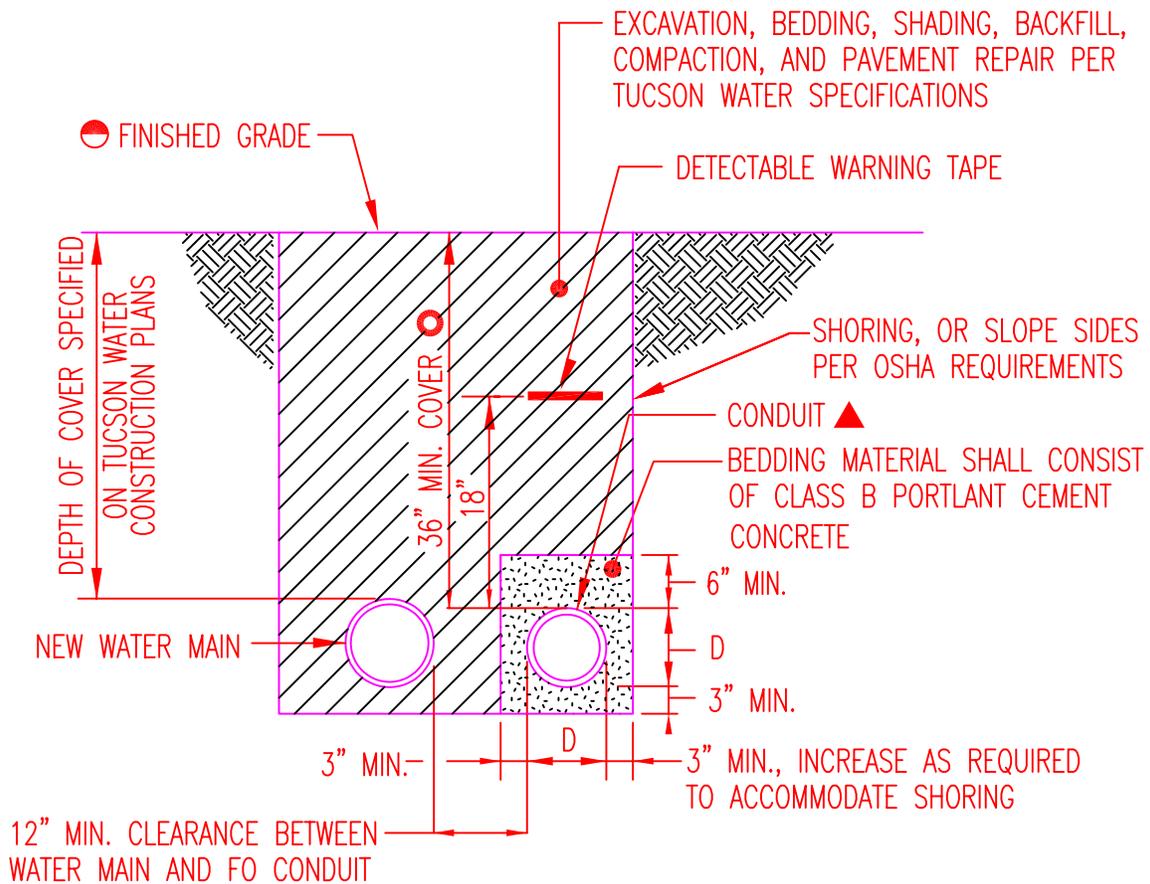
ISSUED:	STANDARD DETAIL		DETAIL NO.:
JAN 1998			FO-100
REVISED:			NOT TO SCALE
April 2007	CONDUIT INSTALLATION		SHEET 1 OF 6



TYPE 2: MULTIPLE FO CONDUITS

REFER TO SHEET 6 OF 6 FOR GENERAL NOTES AND SYMBOLS.

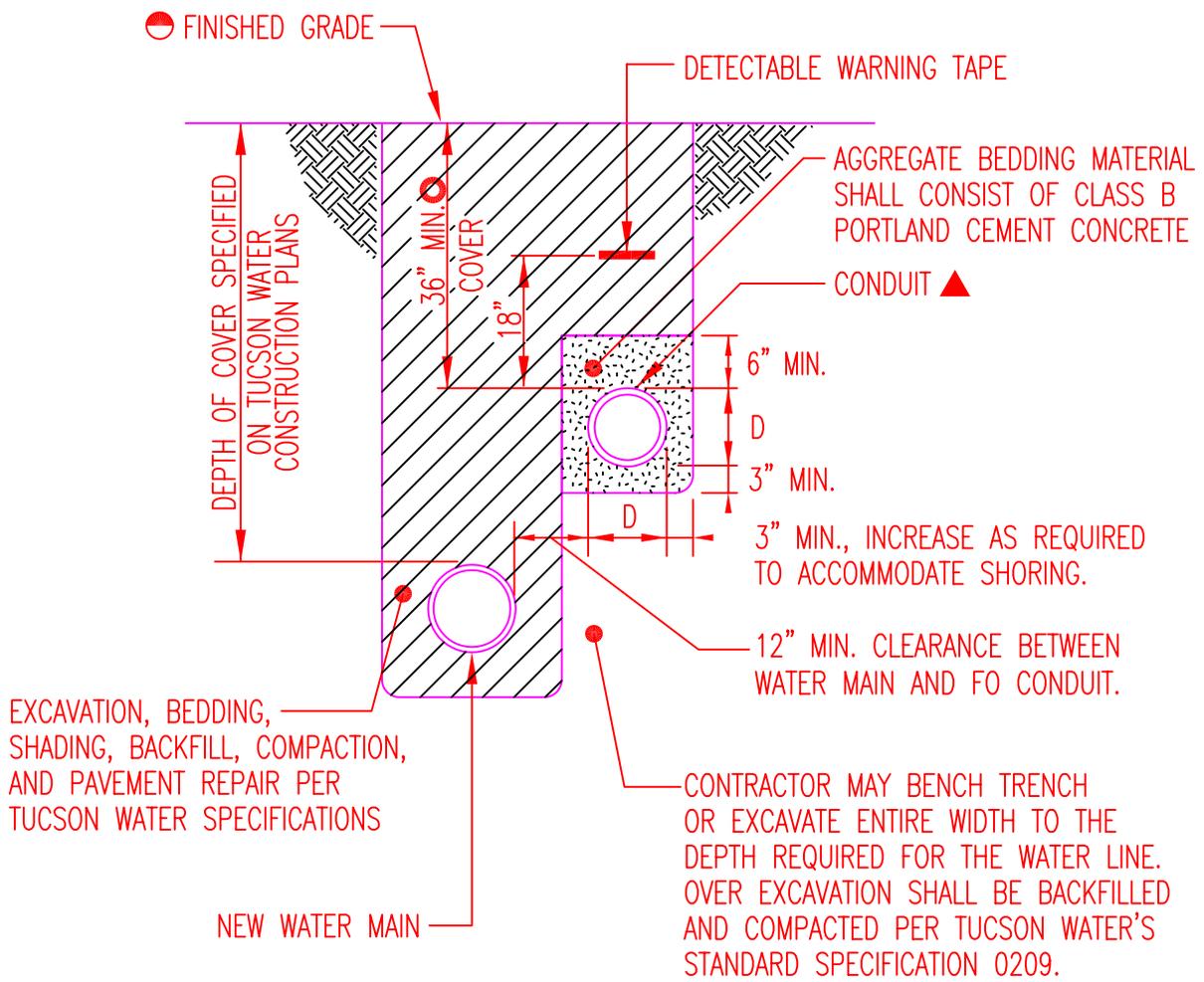
ISSUED:		STANDARD DETAIL		DETAIL NO.: FO-100
JAN 1998		CONDUIT INSTALLATION		NOT TO SCALE
REVISED:				SHEET 2 OF 6
April 2007				



TYPE 3: FO CONDUIT INSTALLED ADJACENT TO TUCSON WATER MAIN

REFER TO SHEET 6 OF 6 FOR GENERAL NOTES AND SYMBOLS.

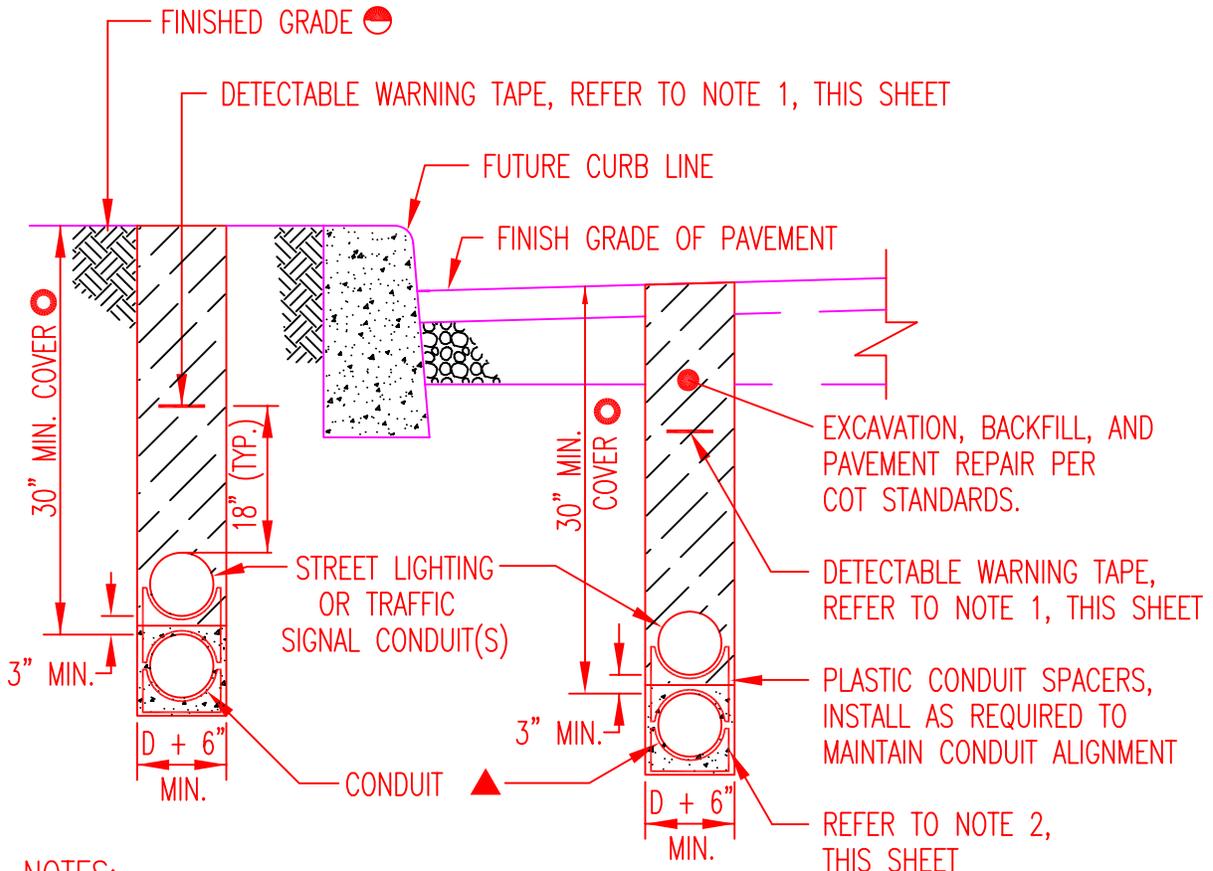
ISSUED:	STANDARD DETAIL		DETAIL NO.:
JAN 1998			FO-100
REVISED:			NOT TO SCALE
April 2007	CONDUIT INSTALLATION		SHEET 3 OF 6



TYPE 4: FO CONDUIT INSTALLED ABOVE TUCSON WATER MAIN

REFER TO SHEET 6 OF 6 FOR GENERAL NOTES AND SYMBOLS.

ISSUED:	STANDARD DETAIL		DETAIL NO.:
JAN 1998			FO-100
REVISED:			NOT TO SCALE
April 2007	CONDUIT INSTALLATION		SHEET 4 OF 6



NOTES:

1. INSTALL WARNING TAPE FOR THE FIBER OPTIC SYSTEM AND THE STREET LIGHTING / TRAFFIC SIGNAL CONDUITS, SIDE BY SIDE AT THE SPECIFIED DEPTH.
2. AT STREET CROSSINGS, WHERE THE STREET LIGHTING / TRAFFIC SIGNAL CONDUIT IS ENCASED IN CONCRETE, ENCASE FO CONDUIT IN CLASS B CONCRETE.
3. EXCAVATION, BEDDING, SHADING, BACKFILL, AND COMPACTION OF THE STREET LIGHTING AND TRAFFIC SIGNAL CONDUITS SHALL BE IN ACCORDANCE WITH THE PIMA COUNTY/CITY OF TUCSON STANDARD SPECIFICATIONS AND DETAILS FOR PUBLIC IMPROVMENT.

TYPE 5: FO CONDUIT INSTALLED WITH STREET LIGHTING OR TRAFFIC SIGNAL CONDUIT

REFER TO SHEET 6 OF 6 FOR GENERAL NOTES AND SYMBOLS.

ISSUED:		STANDARD DETAIL		DETAIL NO.: FO-100
JAN 1998		CONDUIT INSTALLATION		NOT TO SCALE
REVISED:				SHEET 5 OF 6
April 2007				

GENERAL NOTES:

1. FOR ALL CONDUIT ON CITY REAL PROPERTY, AND FOR CONDUIT IN THE ROADWAY RIGHT-OF-WAY WHERE REQUIRED BY THE CITY OF TUCSON/PIMA COUNTY SPECIFICATIONS AND DETAILS, AND WHERE SPECIFICALLY CALLED OUT ON THE DRAWINGS, CONDUIT SHALL BE ENCASED IN CLASS B PORTLAND CEMENT CONCRETE.
2. CONSTRUCTION STAKING SHALL BE IN ACCORDANCE WITH PROJECT REQUIREMENTS.
3. SHORING AND / OR BRACING SHALL CONFORM TO OSHA REQUIREMENTS.
4. REFER TO SPECIFICATIONS FOR THE REQUIREMENTS FOR THE DETECTABLE WARNING TAPE.

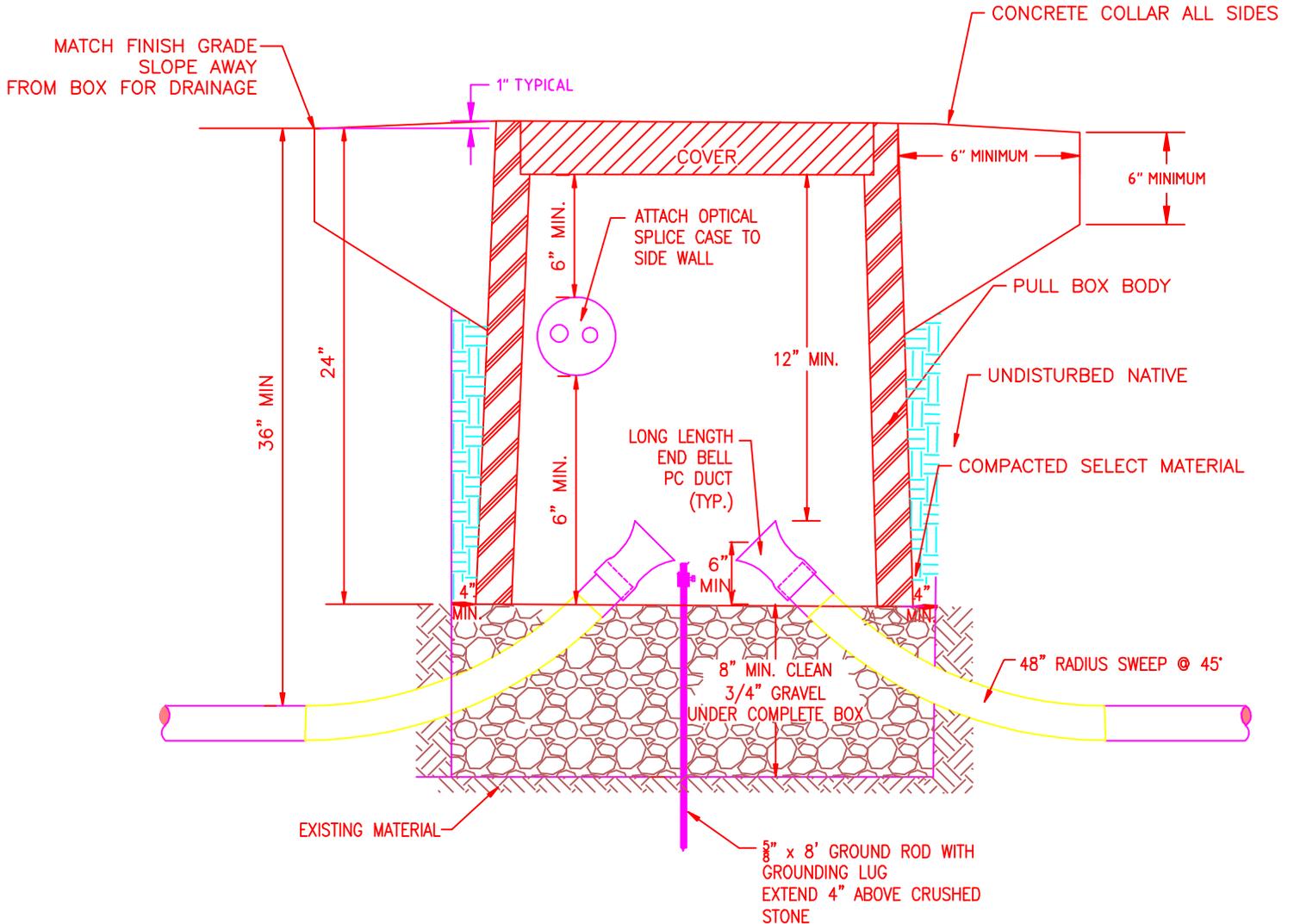
LEGEND:

- D OUTSIDE DIAMETER OF CONDUIT.
- ▲ CONDUIT SHALL BE 4" IN DIAMETER UNLESS OTHERWISE NOTED ON THE PLANS.
- THE LOWER OF EXISTING OR FUTURE FINISHED GRADE.
- PAVEMENT PATCHING SHALL CONFORM WITH THE REQUIREMENTS OF PIMA COUNTY / CITY OF TUCSON STANDARD DETAIL FOR PUBLIC IMPROVEMENTS, STANDARD DETAIL No. 216, AND THE CONSTRUCTION DOCUMENTS.
- 36" MINIMUM COVER, AND A MINIMUM OF 24" BELOW THE LIMITS OF SUBGRADE SCARIFICATION.
-  NATIVE UNDISTURBED SOIL.
-  BACKFILL MATERIAL AND COMPACTION SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF THE AUTHORITY THAT HAS JURISDICTION OVER THE RIGHT-OF-WAY, AND PROJECT SPECIFICATIONS.
-  CONTROLLED LOW-STRENGTH MATERIAL (CLSM), REFER TO TABLE 975-2 TITLED MIX PROPORTIONS FOR CONTROLLED LOW STRENGTH MATERIAL.
-  AGGREGATE BEDDING MATERIAL, REFER TO SPECIFICATIONS.
-  BACKFILL, BEDDING AND SHADING MATERIAL OF A JOINT TRENCH TO BE CONTROLLED BY THE SPECIFICATIONS AND DETAILS OF THE AGENCY RESPONSIBLE FOR THE UTILITY.

ISSUED:		STANDARD DETAIL		DETAIL NO.:
JAN 1998		CONDUIT		FO-100
REVISED:		INSTALLATION		NOT TO SCALE
April 2007				SHEET 6 OF 6

PULLBOX INSTALLATION NOTES

1. PREPARE EXCAVATION APPROXIMATELY 6 INCHES DEEPER THAN OVERALL HEIGHT OF THE ENCLOSURE. THE LENGTH AND WIDTH OF THE EXCAVATION SHALL BE BETWEEN 8 INCHES AND 10 INCHES LARGER THAN THE PULLBOX.
2. PLACE APPROXIMATELY 8 TO 10 INCHES OF COMPACTED 3/4" GRAVEL IN THE EXCAVATION. LEVEL THE GRAVEL TO BRING THE PULLBOX UP TO THE APPROPRIATE GRADE.
3. PLACE THE PULLBOX IN THE EXCAVATION, CENTERING IT.
4. WITH LID INSTALLED ON THE BOX, PLACE SELECTED BACKFILL INTO THE EXCAVATION IN 8-INCH LIFTS, COMPACTING MANUALLY.



USE JACKMOONS AND INNERDUCT PLUGS IN THE BELL ENDS
 TYPICAL OF ALL CONDUITS IN BOX
 REFER TO MANUFACTURERS INSTALLATION RECOMMENDATIONS

PEM-3048

Grade Level Buried Cable Enclosure

Rectangular shape of this enclosure provides maximum usable working area. The unit is designed to accept the new larger splice enclosures. The unit is molded of a high density polyethylene, which has excellent environmental resistance. Reinforcing ribs are designed into the enclosure to withstand backfill operations. Flange around base prevents frost heaving or tilting. This strong but lightweight unit can be handled by one or two people. This results in a considerable savings in installation labor over concrete vaults. Handling equipment is eliminated and allows easy delivery to the construction site. Units come fully assembled and can be nested for a minimum amount of warehouse storage space. The cover is secured to the base with two captive bolts. Units are offered in green molded-in color. Units are shipped palletized for easy handling and storage. Optional split lid is also available for the top. Additional logos are available upon request.

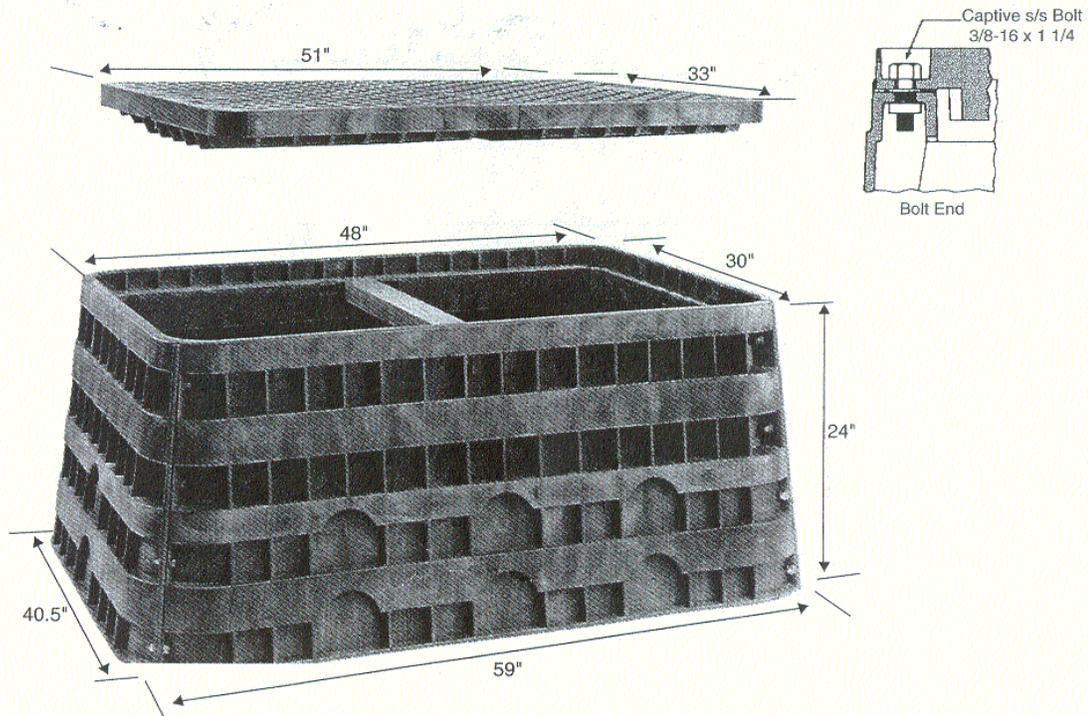
To order specify:

- PEM-3048 — Enclosure with plastic cover.
Identification: (ELECTRIC, CATV, TELEPHONE, IRRIGATION)
Standard: — (H) Hex Head Bolts.
Options: — (X) 3/8 - 16 Penta Head Bolts.
— (B) Button Head Bolts.
— (SL) Steel Lid.
— (FL) Fiberglass Lid.
— (SPLIT) 2 Piece Lid.
Example: — PEM-3048H
Enclosure with plastic cover and S/S hex head bolts.

Test Results

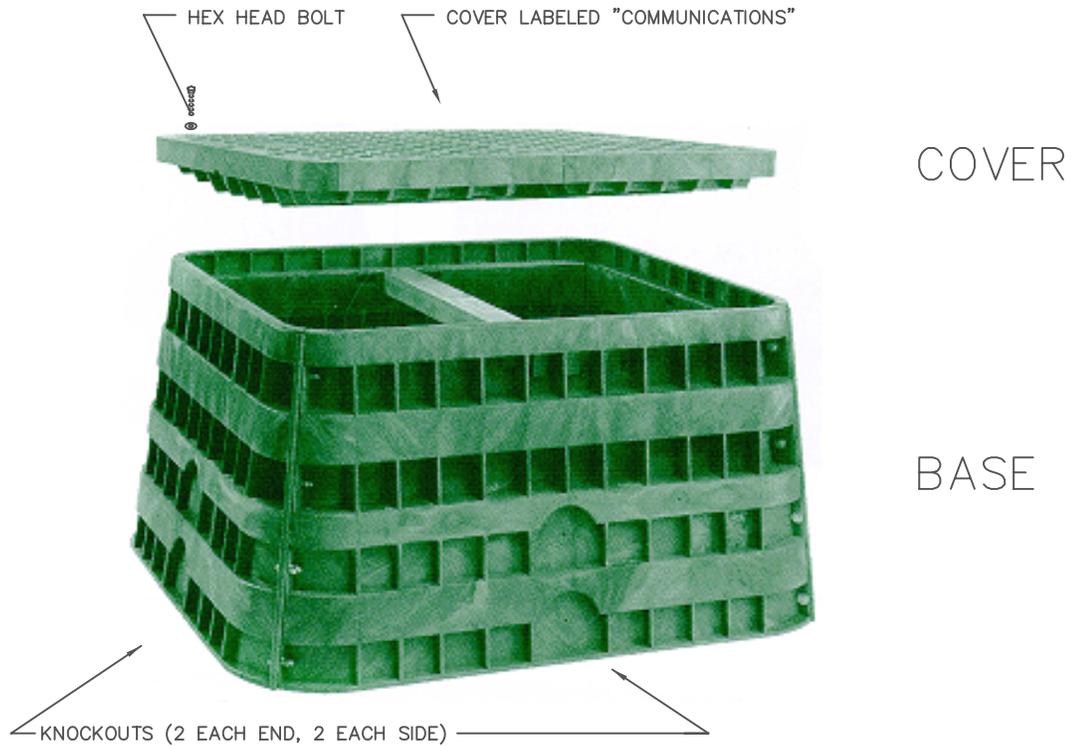
Vertical load on 10x10 center of lid.
5000 Lbs.
No Breakage.

Recommendations on the application of our products are based on the best available technical data and are offered as a suggestion only. Each user of the material should make his own tests to determine the material's suitability for his own particular use.



PenCell
PLASTICS, INC.

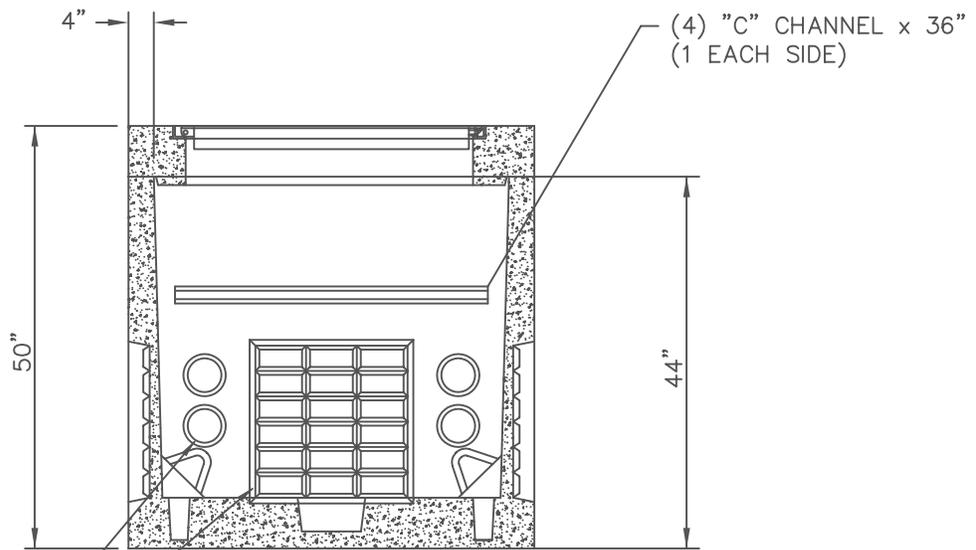
P.O. Box 309
New Egypt, N.J. 08533-0309
(800) 257-9448 • (609) 758-3201 • Fax: (609) 758-7945



GENERAL NOTES

1. BASE AND COVER SHALL BE GRAY IN COLOR.
2. BASE SHALL BE MOLDED HIGH DENSITY POLYETHYLENE.
3. COVER SHALL BE CAST POLYMER CONCRETE.
4. PULLBOX SHALL BE OF THE DIMENSIONS 30" WIDTH BY 48" LENGTH BY 24" DEPTH.
5. COVER SHALL BE FACTORY EMBOSSED WITH "COMMUNICATIONS".
6. COVER SHALL BE SECURED BY 3/8-16 HEX HEAD BOLTS.
7. PULLBOX MAY BE EXTENDED BY MEANS OF SPACER.
8. SPACER SHALL BE 6" IN DEPTH.

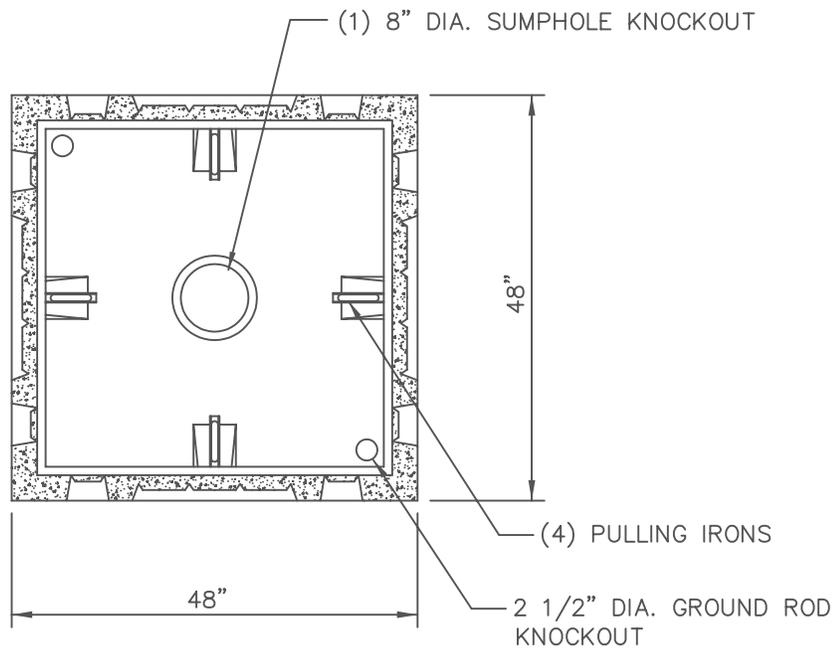
ISSUED:		STANDARD DETAIL		DETAIL NO.:
NOV 2000				FO-300
REVISED:		FIBER OPTIC PULLBOX		NOT TO SCALE
April 2007				General Notes



4 1/2" DIA. KNOCKOUT
(4 EACH SIDE)

18" x 18" KNOCKOUT
(1 EACH SIDE)

SIDE VIEW—VAULT WITH COVER



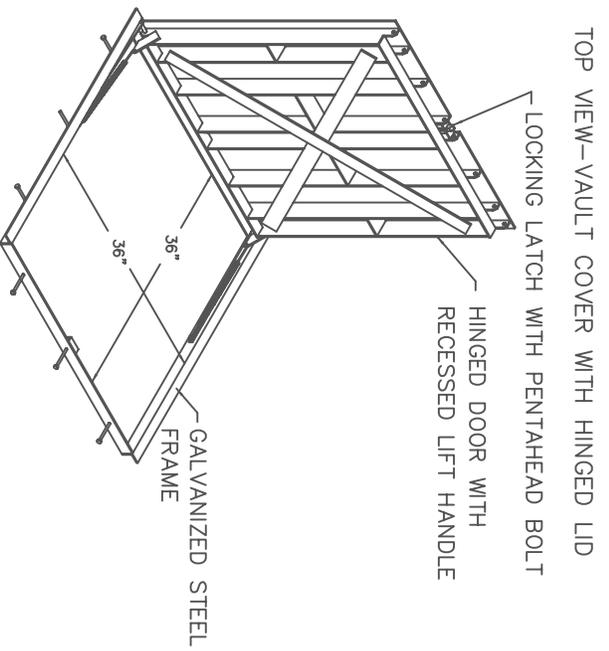
(1) 8" DIA. SUMP HOLE KNOCKOUT

(4) PULLING IRONS

2 1/2" DIA. GROUND ROD
KNOCKOUT

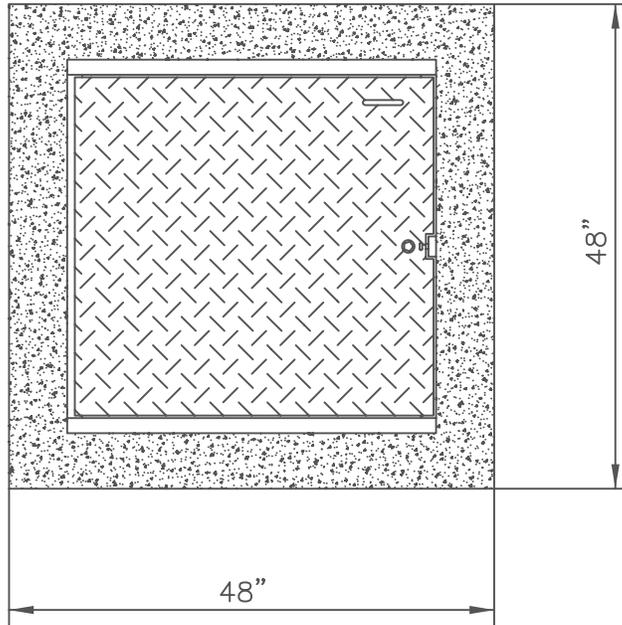
TOP VIEW—VAULT WITHOUT COVER

ISSUED:	STANDARD DETAIL		DETAIL NO.:
NOV 2000			FO-301
REVISED:			NOT TO SCALE
April 2007	FIBER OPTIC VAULT		SHEET 1 OF 3



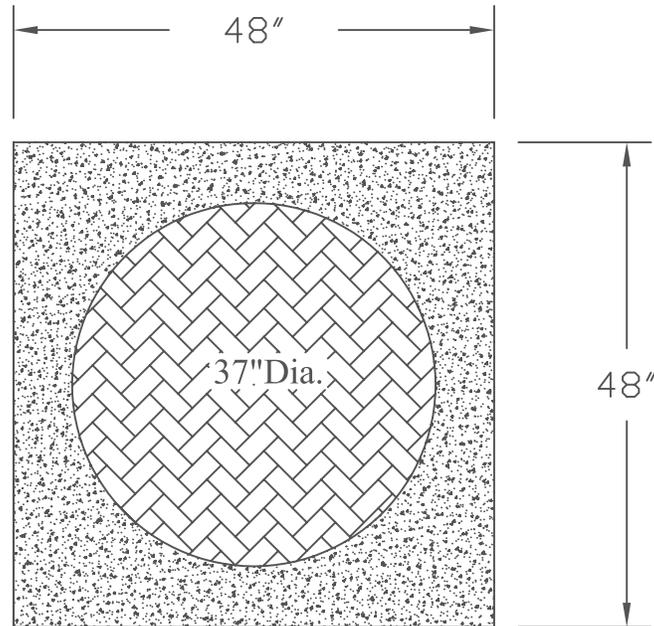
RELIEF VIEW—HINGED LOCKING LID

ISSUED: NOV 2000	STANDARD DETAIL		DETAIL NO.: FO-301
REVISIONS: April 2007			



TOP VIEW—VAULT COVER WITH HINGED LID

TOP VIEW- VAULT COVER



ISSUED:		STANDARD DETAIL		DETAIL NO.:
NOV 2000		FIBER OPTIC VAULT		FO-301
REVISED:				NOT TO SCALE
April 2007				SHEET 3 OF 3

PenCell

Series PEM-30 • Grade Level Buried Cable Enclosure

To order complete units
(enclosure and cover):

PEM-3036

Enclosure with high density polyethylene lid.

PEM-3048

Enclosure with high density polyethylene lid.

PEM-3060

Enclosure with high density polyethylene lid.



24"

30"

60"

To order various covers:

PL - Plastic lid

PCL - Polymer concrete lid

SPLIT - 2 Piece lid

6 INCH SPACER

PEM-3036-6

PEM-3048-6

PEM-3060-6

(All spacers can be stacked for additional depth)

To order various bases:

3036-GS

3048-GS

3060-GS

Available In the Following Bases

Part No.	Description	Dimensions in inches (centimeters)			Weight in Lbs. (kilograms)
		Width	Length	Depth	
PEM-3036	Box & Lid	30" (76.2cm)	36" (91.4cm)	24" (61cm)	115 (52.1kg)
PEM-3048	Box & Lid	30" (76.2cm)	48" (121.9cm)	24" (61cm)	140 (63.5kg)
PEM-3060	Box & Lid	30" (76.2cm)	60" (121.9cm)	24" (61cm)	160 (72.5kg)

To order specify:

Standard: (H) Hex Head Bolts

Options: (X) 3/8-16 Penta Head Bolts
(B) Button Head Bolts

Example: PEM-3036H
Enclosure with H.D. polyethylene lid and hex head bolts.

Identification: (Electric, CATV, Telephone, Water, Irrigation, Communications)
Custom logos on request. Contact factory or agent.

This unit is molded of high density polyethylene. The sidewall design prevents frost heaving. Units can be nested for a minimum amount of warehouse storage space. Units are offered in green molded-in color.

Recommendations on the application of our products are based on best available technical data and are offered as a suggestion only. Each user of the material should make his own tests to determine the material's suitability for his own particular use.

PenCell
PLASTICS, INC.

P.O. Box 309
New Egypt, N.J. 08533-0309
(800) 257-9448 • (609) 758-3201 • Fax: (609) 758-7945 • www.pencell.com