SECTION 05 0521

POST-INSTALLED CONCRETE ANCHORS – HIGH CONFIDENCE

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LANL MASTER SPECIFICATION

Document online at <http://engstandards.lanl.gov>

This section superseded LMS 03 0512 as of Nov 7, 2014. It includes purchase, field installation, inspection, and testing requirements for high-confidence post-installed (PI) anchors. This section must be edited for each project.  In doing so, specifier must add job-specific requirements.  Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer. The section must also be edited to delete requirements for processes, items, or designs that are not included in the project -- and authors notes such as these. To seek a variance from requirements in the section that are applicable, contact the Engineering Standards Manual (ESM) Structural Specs [POC](http://engstandards.lanl.gov/POCs.shtml).

When assembling a specification package, include applicable sections from all Divisions, especially Division 1, General Requirements.

The section was prepared by an organization operating under a quality assurance program that meets the requirements of DOE Order 414.1 and 10 CFR 830 (suitable for ML-1 through ML-4 projects). If the application is ML-3 or ML-4, Section 05 0520 shall be used**\***.

Responsibility for ensuring the section includes all project-specific requirements lies with the organization modifying or implementing the section. When this section is used with nuclear facilities subject to 10 CFR 830 (its intent), modification of it must be performed by an individual or organization operating under a quality assurance program that meets the requirements of that CFR and receive independent technical and QA reviews.

**\*** At the time of publication, the only PI anchor approved for use for LANL NPH Design Category (NDC)-3 applications was the Hilti HDA (refer to ESM Ch. 5 Sect. III, App. A); therefore, this section was written for use of the HDA. Given this, and the fact that several aspects of HDA installation are unique to this anchor, users of this section must be mindful of the following:

1. Section 05 0520 (not this one) shall be used for all ML-3 and ML-4 applications since it’s based on ESM Ch. 5 Sect. ***II***, Appendix A; ACI 318; and ICC-ES ESR-1546 (vs. Ch. 5 Sect. ***III***, Appendices A & B, and ACI 349). In short, HDAs designed for NDC-3 use might not comply with ESM Ch. 5 Sect. II App. A.
2. Use of this section for ML-1 and ML-2 applications using a PI anchor other than the HDA will require significant editing. If/when ESM is changed (i.e., to include the use of a product other than/in addition to HDA), contact LANL Structural Specs POC for assistance in revising this section. For grouted embedments, refer to ACI 349, Sect. D.12 for testing requirements, and for specification requirements.

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PART 1 GENERAL

1. SUMMARY

## This Section includes the technical requirements for purchasing, installing, and testing post-installed concrete anchors in Management Level (ML) -1 and ML-2 applications at LANL.

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Edit the following Paragraph to include the project-specific need for a high-confidence (H-C) anchor(s). The options provided are some of the more typical LANL applications that require H-C anchors.

If the project includes anchorage of more than 1 element/item/component, and the elements aren’t co-located, ensure that the following para. has enough specificity to ensure there’s no confusion with regard to the elements that require H-C anchors & their respective locations.

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1. The nuclear-safety element[s] in this project that require[s] [a] high-confidence anchor[s] [is] [are] [a] glovebox[s][,] [uninterruptable power supply (UPS)][,] [and] [a] [\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_].

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The normal-weight-concrete limitation in the following Para. comes from ACI 349 App. D.

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## This Section applies to undercut mechanical anchors installed in normal-weight concrete. Definitions for undercut anchors per ACI 355.2 apply. All notations are identical to those used in ACI 349 Appendix D. Where additional terms or notations are used, their definitions are included in this text.

* 1. This Section does not cover (1) design of post-installed anchorage, (2) post-installed anchors in light- or heavy-weight concrete, or (3) anchors for ML-3 or -4 applications.

## RELATED SECTIONS

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Regarding Sect. 01 4000 in the following Para., there are two (2) Sections 01 4000 in the LANL Master Spec, a non-nuclear one & a nuclear one. While it’s obvious that the latter applies herein, the wrong section could still be included in the project specification since they’re numbered the same (01 4000),

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* + - * 1. 01 4000 *Quality Requirements - Nuclear*
				2. 03 6021 *Grouting* - *High-Confidence*: All requirements (e.g., submittals, quality control, products, installation, etc.) for grout used as indicated in PART 3 herein.

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Retain 05 0520 only if Project includes “normal-confidence” PI anchors.

If Project includes some “normal-confidence” Hilti HDA anchors, not only is 05 0520 required, but the design of any “05 0520 HDAs” must comply with ESM Ch. 5 Sect. *II* App. A (vs. Sect. *III* Apps. A & B).

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* + - * 1. [05 0520 *Post-Installed Concrete and Grouted-Masonry Anchors– Normal Confidence*]
				2. [05 1000 *Structural Metal Framing*: Baseplates, bearing plates, leveling plates.]
1. ACRONYMS, DEFINITIONS AND SYMBOLS
	* 1. Certificate of Conformance (C of C): A document from a supplier and/or manufacturer that identifies the Subcontract or purchase order number and states that the item or service described thereon conforms in all respects with Subcontract/manufacturer requirements, which may include any applicable specifications, drawings, marking requirements, part/model/serial number identification, or codes/standards to which the item is certified. Where applicable, the C of C shall identify the material by part/control number consistent with part number information in Subcontract documents and/or specifications. Each C of C shall furtheridentify any approved changes, waivers, or deviations to the item requirements and identify any requirements that have not been met, with a corresponding means/recommendation for resolving the nonconformance. Each C of C shall be signed or otherwise authenticated by an authorized person responsible for this function as described in the Supplier’s quality assurance program.
		2. Certified Material Test Report (CMTR): A document issued by the original manufacturer of the material that identifies the actual chemical and/or physical properties and any test(s) performed to the applicable nationally recognized standards or as specified by the Subcontract. The CMTR shall be traceable to the material supplied through heat number, batch number, manufacturer's lot numbers, or other method as allowable by manufacturer’s quality assurance program or national recognized standard. The CMTR shall be signed by the manufacturer's authorized representative as defined by the manufacturer’s quality assurance program or as otherwise authorized.
		3. Design Basis Earthquake (DBE): That event, described in terms of ground motion, required to be used for the design of safety-related structures, systems and components.

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In the last sentence of the following Para., delete the brackets if project’s usage of this section will be performed by LANL (i.e., “self-performed work”).

In addition, if “self-performed” applies, replace the numerous references throughout the section to “LANL STR” with EOR; and delete the definition of “LANL STR” in this Article. \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

* + 1. Engineer/Engineer of Record (EOR): The licensed professional engineer, employed by the owner-contracted design authority or other agency, responsible for the overall design of the facility or Project (e.g., issues Construction Drawings, Specifications, or other documents, etc.). EOR and Architect/Engineer are synonymous. [For this Project the EOR and LANL are the same entity.]
		2. Hold Point: A mandatory verification point in the progression of a process activity that cannot be passed without being released by the responsible party that established the Hold Point. It is mandatory that the Subcontractor formally notify LANL five (5) business days prior to a scheduled Hold Point, or within a time period agreed to by LANL. A Hold Point cannot be bypassed without the specific release by the approved official of the designating organization.
		3. Los Alamos National Laboratory (LANL): The managing contractor of LANL is [Los Alamos National Security, LLC]; however, “LANL” is used herein, which acts as Owner. LANL also means Subcontract Administrator, the individual authorized to act on the behalf of LANL
		4. LANL Building Official (LBO).
		5. LANL Subcontract Technical Representative (STR).
		6. Statement of Special Inspections (SSI).
		7. Witness Point: A verification point in the sequence of Work which is designated for LANL to do monitoring and which Work may PROCEED ONLY after notifying the LANL STR. It is mandatory that the Subcontractor formally notifies the STR two (2) business days in advance of all Witness points, or within a time period agreed to by LANL.
	1. REFERENCES

The publications listed below form a part of this Section to the extent referenced. The publications are referred to in the text by the basic designation only.

1. American Concrete Institute (ACI)
	1. ACI 355.2 Qualification of Post-Installed Mechanical Anchors in

Concrete

* 1. ACI 349 Code Requirements for Nuclear Safety Related Concrete

Structures

1. American Institute of Steel Construction (AISC)
	1. AISC 360 Specification for Structural Steel Buildings
2. American Society of Mechanical Engineers (ASME)
	1. ASME NQA-1 Quality Assurance Requirements for Nuclear Facility

Applications

1. ASTM International (ASTM)
	1. ASTM A 193 Standard Specification for Alloy-Steel Bolting Materials for

 High-Temperature or High Pressure Service and Other

 Special Purpose Applications

* 1. ASTM E 3121 Standard Test Methods for Field Testing of Anchors in

 Concrete or Masonry

* 1. ASTM F 436 Standard Specification for Hardened Steel Washers

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Edit the following paragraph to include the project-specific safety function(s) that the high-confidence (H-C) anchor(s) must perform. The options provided are some of the more typical LANL functions.

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1.5 SAFETY FUNCTION PERFORMANCE REQUIREMENTS

[A. The anchor[s] provide[s] restraint against overturning [and sliding] during normal operation, as well as during and after the DBE.]]

[B. The anchor[s] ensure[s] position retention during normal operation, as well as

 during and after the DBE.]]

 [C. The anchor[s] [ensure[[s] [provide][[s] \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.]]

 1.6 ACTION SUBMITTALS

1. Verification Documents for Purchase
	1. The following verification documentation shall be submitted by the Supplier of the anchor(s) to be installed:
		1. CMTR and C of C indicating the materials comprising the anchor (i.e., cone, bolt, and sleeve) and its components (i.e., the nut and washer); the finish of the anchor and its components (i.e., zinc plated or stainless steel); and that the anchor and its components were procured from a LANL-approved supplier following an ASME-NQA-1 compliant process.
2. Verification Documents for Installation
	1. The following verification documentation shall be submitted by the Subcontractor responsible for anchor installation:
		* + 1. Manufacturer’s printed installation instructions (MPII).
				2. Installer-training documentation in accordance with the PART 3 Article “Installers.”
				3. A Verification of Inspection and Test (VIT) Plan in accordance with Section 01 4000, *Quality Assurance*.
				4. Qualification records for inspection and test personnel per Section 01 4000, *Quality Assurance*.
				5. Installation Inspection Record and Testing inspection records, and failed anchor documentation in accordance with the applicable portion of the PART 3 Article “Documentation.”

## 1.7 QUALITY ASSURANCE

1. In addition to the subsequent portions of this Article (Quality Assurance), refer to Section 01 4000 *Quality Assurance* for quality-assurance requirements.
2. All safety-related material shall be procured as high confidence from a supplier using a process meeting ASME NQA-1-2008 with the 2009 addenda.
3. The installation of products/materials shall be in accordance with this Section, MPII, and any/all LBO conditions documented in the LBO Approval Listing with ESM Chapter 16 [https://engstandards.lanl.gov/ESM\_Chapters.shtml#esm16](https://engstandards.lanl.gov/ESM_Chapters.shtml%23esm16). Any departures from these documents shall be acknowledged via a formal variance in accordance with ESM Chapter 1 Section Z10. Any conflicts amongst/between these documents shall be brought to the attention of the LANL STR for resolution.
4. The inspection, testing, and documentation requirements contained herein are the responsibility of the Subcontractor installing PI anchors (i.e., versus the PI-anchor inspection requirements contained in the project’s SSI, which are the responsibility of the LANL Special Inspector).
5. To reduce delays and potentially redundant Special Inspection effort, notify LANL Inspectors at least 24 hours prior to any Subcontractor installation, inspection, or testing activities associated with SSI and treat such tasks as hold/witness points.

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Edit the following Para., as well as the subparas. therein, in accordance with project requirements, specifics, etc., as well as previously-edited related content in the section.

The options in the subparas. are those that will likely be applicable in all applications.

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1. Critical characteristics required for the anchor[s] to perform [its] [their] credited safety function are:
	* + 1. The anchor[s] and [its] [their respective] properties (i.e., configuration, material, diameter, embedment depth of undercut, and maximum fixture thickness) must be that which is designated in the PART-2 Article “Undercut Anchor”, herein.
			2. The installation of the anchor[s] must be in accordance with all applicable provisions included in PART 3 herein.
2. Witness and hold points for the work shall be as follows:
	* + 1. Hold point to verify anchor material (i.e., CMTR) at receipt on site.
			2. Hold point to verify anchor installation in accordance with this section.
			3. Witness and hold points stipulated in PART 3 of this section.
			4. Witness and hold points stipulated in the VIT Plan.

1.8 DELIVERY, STORAGE, AND HANDLING

1. Anchors are classified as Level C and shall be controlled in accordance with manufacturer's instructions and ASME NQA-1, Part II, Subpart 2.2, *Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items*.
2. Deliver anchors in manufacturer's unopened packaging with proper labels intact, and undamaged.
3. Only the nuts and washers packaged with anchors shall be used.
4. Anchors, nuts and washers shall be stored in such a manner as to permit inventory control and to preclude damage or degradation. Protect from contaminants such as grease, oil, and dirt.

# PART 2 MATERIALS / PRODUCTS

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The location for fully designating/specifying the HDA in the format of HDA-(\_)(\_) M( ) x (\_\_\_) / (\_\_) is prior to the end of the Article (*2.1.G)*. Follow this approach or obtain written permission for otherwise from LANL Structural Specs [POC](http://engstandards.lanl.gov/POCs.shtml).

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* + 1. Undercut anchor
1. Hilti HDA, NO SUBSTITUTIONS. The next five (5) paragraphs of this Article provide the details required to fully specify/designate the anchor: HDA-(configuration type)( material type) M(anchor diameter) x (minimum embedment depth of undercut) / (maximum attachment/fixture/baseplate thickness).

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Use of the HDA-DUC in the “T” configuration type isn’t possible unless the order size is enormous and the Project can afford the extra lead time for production. Thus, for most LANL projects, if “T” is required, then the design will likely have to be based on either the “standard HDA (high-strength carbon steel)” and/or the HDA-R (stainless steel).

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1. Configuration type [P] [and] [T].
	1. [P = Pre-set (i.e., anchor is installed prior to installation of fixture/ baseplate)].
	2. [T = Through-set (i.e., anchor is installed through fixture/baseplate.]

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Use of zinc-plated carbon steel is limited to dry, indoor locations.

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1. Material type [blank/not applicable,] [R] [and] [DUC].
	1. [Blank = “standard”/zinc-plated, high-strength carbon steel.]
	2. [R = Type 316/316Ti stainless steel.]
	3. [DUC = “ductile" / zinc-plated, “normal-strength” carbon steel.]

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1. Anchor diameter[s] (in metric units of millimeters, or mm) [M10,] [M12,] [M16,] [and] [M20].

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The largest embedment depth – 250 mm – is only available for the M20 diameter. See previous author note on the availability of the M20 diameter.

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1. Minimum embedment depth[s] of undercut (in mm) [100,] [125,] [190,] [and] [250].

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The M10 diameter has one (1) maximum fixture thickness: 20 mm. Each of the other diameters have two (2) max. fixture thicknesses: M12: 30 & 50 mm; M16: 40 & 60 mm; & M20: 50 & 100 mm.

See previous author note on the availability of the M20 diameter.

For the HDA-DUC, the 50-mm fixture thickness for the M12 diameter requires extra lead time for production. And there’s even more lead time for production for the 60-mm fixture thickness for the HDA-DUC M16.

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1. Maximum fixture thickness[es] (in mm) [20,] [30,] [40,] [50,] [60,] [and] [100].

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Here are complete designations of the largest design and specification options that conform to the previous five (5) author notes: HDA-P M20 x 250 / 100, HDA-T M20 x 250 / 100, HDA-PR M16 x 190 / 60, HDA-TR M16 x 190 / 60, and HDA-P DUC M16 x 190 / 40.

Here are complete designations of the smallest design and specification options that conform to the previous five (5) author notes: HDA-P M10 x 100 / 20, HDA-T M10 x 100 / 20, HDA-PR M10 x 100 / 20, HDA-TR M10 x 100 / 20, and HDA-P DUC M10 x 100 / 20.

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1. Complete anchor designation[s]: HDA-[\_][\_] M[\_] x [\_\_\_] / [\_\_]
2. Each anchor shall have “Hilti,” the complete anchor designation, and the lot number embossed on its sleeve.
3. TEST AND INSPECTIONS
4. The product supplier is responsible for performing product inspections, as necessary to ensure compliance with all material and documentation requirements identified in this Section.
5. LANL STR shall have the option of inspecting anchors for finish, workmanship, and dimensional tolerances before any shipment is made. The documentation required by this Section shall be available for review.
6. Materials that are not properly marked, have poor workmanship, are corroded, have defective threads, or are improperly documented shall be rejected.

PART 3 EXECUTION

# 3.1 INSTALLERS

1. Implement and document a training and/or qualification program for installers. Installers shall be trained on, and made fully familiar with, the MPII\* and additional requirements noted in this Section. Training shall be completed and documented before proceeding with work.

\* NOTE: The MPII for the pre-set-type HDA and the through-set-type HDA differ; therefore, separate training/qualification is required for each anchor type.

# 3.2 GENERAL

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Since the design and performance of PI anchors are dependent upon the concrete type (i.e., normal-weight vs. light- or heavy-weight), compressive strength (i.e., f’c), and thickness, these properties/data are included in the Special Inspections section of the ICC-ES Engineering Service Reports (ESRs) for these products.  Given this, and the fact the installer and inspector might not know these properties (particularly for projects on/in existing structures), the EOR must indicate them on the construction drawings for every location in which an anchor is to be installed.  In the event that none of these properties change from one anchorage location to another, the EOR need only indicate the “concrete properties associated with PI anchors” once on the drawings. Document the source/bases for these data in the anchorage calculation.

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* 1. The use of anchors shall be restricted to the applications and installations indicated. Construction aids are exempt from this requirement.
	2. The minimum values of embedment depth, spacing, and edge distance shall be as indicated.

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The EOR must ensure that the product designed and specified is available in a length adequate to satisfy the following “nut-thread-engagement provision.” Otherwise the project will likely experience delays and/or additional costs.

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* 1. The nut thread engagement for the anchors (studs) shall be such that the anchor threads are flush with, or project beyond, the outside face of the nut when completely installed.
	2. Nuts and washers for anchors that are lost or damaged during installation shall be replaced with Hilti’s specified component or equivalent as pre-approved by the LANL STR (Hold Point).
	3. Anchors may not be installed in new, “28-day-mix concrete” until it has cured for at least seven (7) days, and may not be loaded until the concrete has attained its minimum specified design strength.
	4. Anchors shall be installed in only normal-weight, sound concrete. Surfaces showing obvious distress by way of porosity, disintegration, carbonation and cracks over 0.02 inches in width and 12 inches or longer and within the distance of the embedment depth shall be reported to the LANL STR for evaluation (Hold Point).
	5. Anchors may not be installed into the sides or bottoms of precast and pre-stressed T-beam stems without the pre-approval of the LANL STR (Hold Point). Strand-cutting/nicking is prohibited.
	6. Bending and welding of anchors is prohibited.

# 3.3 PREPARATION

1. The Hilti HDA shall be installed using MPII, which requires the use of HDA system. The HDA system includes the anchor, stop drill bit, setting tool and the hammer drill.
2. Devices required for installation, inspection and testing (e.g., torque wrenches, hammer drills, setting tools, etc.) shall be calibrated and controlled in accordance with LANL Procedure P330-2, *Control and Calibration of Measuring and Test Equipment (M&TE)*, or equivalent.
3. Obtain and comply with LANL Form 2074, Penetration Permit.
4. Locate existing reinforcing steel (rebar) in the concrete prior to drilling using a ground-penetration-radar (GPR) device.\* Pilot holes shall be drilled with a carbide-tip bit to avoid rebar damage, and the depth of such holes shall not exceed 66% of the specified anchor embedment depth.

\* NOTE: Hilti PS 1000 X-Scan Radar Detection System will locate more than just rebar, provides 2-D and 3-D visualization of concealed items, and is effective with concrete as thick as 12 inches.

1. In rad and cleanroom areas, use of Hilti dust collection hood (i.e., a vacuum attachment, Hilti Item No. 362323) during hole cleaning/blow-out is normally required. Consider purchase (along with HDA system) if item is not on hand.
2. For safety, consider drill bits/drills that automatically shut off when the bit hits metal, particularly in older construction for which electrical configuration is not well-documented.
3. Rebar cutting is only permitted with pre-approval by the LANL STR (Hold Point). Local**\*** multi-cutting of the same bar is considered as one cut. Rebar shall be cut with a Hilti matched-tolerance, diamond, core bit. Drilling of the hole shall be accomplished with the appropriate Hilti stop drill bit and in accordance with the procedure stipulated by Hilti. Rebar approved to be cut must be shown on as-built drawings at completion of Project.

**\***Within the footprint of the fixture/baseplate.

1. Rebar will be considered to be cut if:
	1. For #4 through #7 – Cuts, nicks, or drill into bar body is greater than 1/16”
	2. For #8 and larger – Cuts, nicks, or drill into bar body is greater than 1/8”

Cutting of bar deformations is not considered a cut since the area of steel is not reduced.

1. The installation of an anchor through cut rebar shall be performed in accordance with the Hilti’s written procedure.

# 3.4 DRILLING OF HOLES

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Drill-hole depths for HDAs are 0.3 to 0.7 inches deeper than the effective minimum embedment depth (hef), depending on the diameter. This may limit the hef that can be achieved.

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* 1. Locations and embedment depths of anchors shall be as indicated. The drill-hole diameters and depths shall be in accordance with the MPII unless otherwise specified herein. Verify depth of the concrete before drilling holes, and contact the LANL STR in the event of a conflict between/amongst the various depths (i.e., embedment, drill-hole, and concrete) (Hold Point).
	2. Drill holes for anchors in accordance with the MPII.
	3. Clean drilled holes of chips, dust, loose material, and water prior to anchor installation.

# 3.5 INSTALLATION OF ANCHORS

1. Washers supplied with anchors shall be installed in all instances. A supplementary/additional washer (i.e., a washer not supplied with anchor), if indicated for use, shall be installed underneath the washer supplied with the anchor. Supplementary washers may be trimmed to clear interferences. Per ASTM F 436, the trimmed edge shall not be closer than 7/8 of the anchor diameter from the center of the washer.
2. Anchors shall be installed plumb, which is defined as follows: perpendicular to the nominal concrete surface within a ± 5-degree tolerance. This criterion may be verified by visual inspection of the nut and washer being properly seated on the nominal surface of the fixture (i.e., flush all around).
3. Care shall be exercised to avoid bending anchors to match baseplate holes, or loosening of anchors by prying sideways after tightening.
4. When installing an anchor in a grouted hole, the undercut shall be located in “original concrete.” To ensure this occurs, the anchor-setting depth shall be at least two (2) anchor diameters or 3”, whichever is greater, clear beyond the bottom of the grouted hole. If the depth of concrete won’t allow for setting this deep, the LANL STR shall be contacted for an alternative (HOLD POINT).
5. The center-to-center distance between a new-anchor hole and an exploratory or unused hole, or an abandoned cut-off anchor, shall be at least three (3) times the diameter of the larger hole or 1” clear distance of concrete between the holes, whichever is greater.
	1. Exception: The clear-distance requirement (i.e., 1” of concrete between the holes) need not be considered if an exploratory/unused hole is grouted with a non-shrink grout specified in Section 03 6021 *Grouting* – *High-Confidence*, the grout has attained the strength of the surrounding concrete, and if the center-to-center distance between the new hole and the exploratory/unused hole, or abandoned anchor, is 3 times the diameter of the larger hole.

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The intent of the minimum spacing indicated in the following paragraph are to ensure there’s no reduction in anchor capacity.

Summing the respective hef values is very conservative if/when hef for one anchor >> hef for the other. In such cases, it’s possible that there won’t be a reduction in capacity if the anchors are spaced ***closely*** enough (i.e., the concrete-breakout-failure prism of the “shallow anchor” might be contained within/not interact with that of the “deep anchor”).

Finally, the reason for the last sentence is because the “1.5hef + 15hef “ requirement comes from the Savanah River Site (SRS), and it’s based on their Guide 03251 tabulation of the capacities of several types, sizes, and shapes of anchors, which doesn’t include steel as strong as “A 193,” diameters > 5/8”, and hooked configuration/shape.

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1. The center-to-center distance between a new-anchor and an existing anchor shall be at least the sum of 1.5 times the embedment depths of the new and existing anchors. If the embedment depth of the existing anchor can’t be determined, the minimum center-to-center distance shall be 1.5 times the embedment depth of the new anchor plus 15 times the diameter of the existing anchor. If either of the two anchors is of ASTM A 193 material, or greater than 5/8” diameter, or if the existing anchor is a hooked (“J,” cast-in-place) anchor rod, contact the LANL STR for evaluation (HOLD POINT).
2. Non-grouted fixtures/baseplates installed with anchors may have a maximum 1/8-inch gap under exterior/perimeter edges provided there’s full bearing (on the concrete surface) over the rest of the fixture and that the prescribed anchor-installation torque can be applied. If the gap is excessive/too large, and/or the prescribed torque won’t result in complete/satisfactory anchor installation, one (1) of the following two (2) procedures shall be undertaken:
3. The concrete surface shall be reworked.
4. For gaps of up to one (1) inch, the fixture may be grouted per the following procedure:
	* 1. Insert anchors and set the fixture.
		2. Install nuts to finger-tight condition.
		3. Install shims positioned no more than 1/2 inch away from the anchors to reduce gaps between fixture shims to 1/8 inch or less at anchor locations.
		4. Apply prescribed installation torque slowly enough to determine whether or not the shims are close enough to the anchors. If initial torqueing results in downward bending of the fixture, the shims aren’t close enough. Untorque the anchors, and relocate the shims as necessary to permit re-torqueing without fixture bending.
		5. Fill the gap with a non-shrink grout specified in Section 03 6021, *Grouting* – *High-Confidence* leaving the shims in place. For fixtures on walls, where grouting is not feasible, the gap may be filled with shim plates. The shims may be stacked with up to four (4) shims per stack.
5. Leveling nuts aren’t permitted under fixtures/baseplates (since they could preclude application of prescribed installation torque).

3.6 RELOCATING FIXTURE/BASEPLATE

1. Unless otherwise indicated, a fixture (to be anchored) may be relocated up to one (1) inch in any direction with respect to its principal axis.

3.7 RELOCATING HOLES WITHIN FIXTURE/BASEPLATE

1. If anchors located as indicated will result in rebar being hit, individual fixture/baseplate holes may be relocated subject to the following limitations:
	1. If tolerances or ranges aren’t indicated for them, anchor holes in the fixture may be relocated up to one (1) inch in any direction provided the anchor-spacing criteria, and edge-distance criteria for both the fixture and the concrete, will be met.

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The following subparagraph, to include the fig. referred to therein, is based on AISC 360; therefore, if the fixture/baseplate is something other than “AISC-360 material,” editing is required.

For example, if the fixture is cold-formed steel (CFS) then the applicable standard is AISI S100 (Ch. E). In this example, an edit merely replacing AISC 360 with AISI S100 wouldn’t suffice (unless Figure 1 and related sentence in “2” below are deleted).

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* 1. The minimum edge distance from the center of a hole to the edge of the fixture shall comply with AISC 360 Chapter J Table J3.4. Alternatively, back-up bars, as shown in Figure 1 (appended herein), shall be used; back-up bars shall be field-cut from stock material to match that of the fixture. Another alternative, if feasible/not otherwise prohibited, is to use a larger fixture size.

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The major difference between the following paragraph & the previous one is the existence of a fixture hole(s): In former paragraph, the fixture hole doesn’t exist, while in the subsequent paragraph it does (as a result of the project or otherwise).

The 1st and 3rd subparagraphs in the following paragraph are based on the fixture being AISC‑360 material. With regard to the 1st subparagraph, AISC 360-16 Sect. J2.2 indicates that arc spot/puddle welds are similar to plug welds; however, prior to editing (from AISC 360 to AISI S100), EOR must research whether or not it’s permissible to close CFS holes with puddle welds and to drill new holes through such welds. And similar applies to the 3rd subparagraph (on flame cutting.)

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1. The relocation or abandonment of existing anchor holes in a fixture/baseplate shall meet the following requirements:
	1. Holes may be relocated by abandoning the existing hole and redrilling a new hole. The existing hole may be closed by plug welds, and the surface ground smooth. It is permissible to drill new holes through the hole that was plug welded.
	2. If the existing fixture hole resulted in a drill hole in the concrete, the minimum center-to-center spacing between a new hole and an exploratory/unused hole stipulated in the prior Article, “Installation of Anchors”\* shall be met.

\* NOTE: The Paragraph in “Installation of Anchors” that includes the minimum spacing referred to here also includes an exception. That exception is applicable here too (if the conditions associated with it are met).

* 1. Flame cutting of holes in the fixture is permitted provided that those holes are reamed and/or ground to the final required dimensions.

3.8 INSPECTION AND TESTING

1. INSPECTION
2. Visually inspect each anchor using Table 1 (appended herein) to verify that installation was performed in accordance with this Section.
3. If visual inspection reveals that a provision isn’t met/satisfied, the infraction shall be remedied in a manner that’s consistent with the requirements of this Section. If hole drilling has occurred, or if anchor installation has been completed, remediation might consist of anchor relocation, or anchor removal and replacement, in accordance with the subsequent Article “Rework and Abandonment of Anchors, and Repair.”
4. The inspection(s) and its results shall be documented in an Installation Inspection Record in accordance with the subsequent Article “Documentation.”

## TESTING

1. Testing of anchors that are permanent (e.g., not temporary construction aids, etc.) is mandatory and shall be witnessed by the LANL Construction Inspector.
2. The following two (2) methods of testing are acceptable. One or both may be used in a project/test program. Whether or not testing can be performed before or after installation of the fixture/baseplate depends solely on the testing method selected for use:

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In the following “torque-method Paragraph,” the 1-hr stipulation is to ensure the “authenticity/integrity” of the testing. The same goes for the stipulations on use of a different wrench, & the person that performs the test. Thus, all 3 stipulations are flexible/changeable depending on the specifics of a given application/project.

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### Torque method: This method shall only be used after installation of the fixture, and shall not be performed sooner than one (1) hour after installation of the anchor. The anchor shall be tested with a manually-operated, calibrated torque wrench other than the one used for installation of the anchor, and the testing shall be performed by someone other than the anchor installer. The amount of applied torque shall be at least 80% of the prescribed installation torque (as specified in the MPII).

### Proof-load method: This method can be used either before or after installation of the fixture, and shall be performed in accordance with ASTM E 3121. The anchor shall be tested with a calibrated tensioner. The amount of applied tensioning load shall be that which is specified by Hilti\*.

### \* NOTE: The tensioning load specified by Hilti corresponds to the minimum embedment depth and/or minimum concrete compressive strength specified (by Hilti); thus, if the actual embedment depth and/or the actual concrete strength is smaller than the Hilti-specified minimum, the tensioning load must be reduced. If such a reduction is necessary, contact Hilti and the LANL STR for guidance/evaluation (HOLD POINT).

### Post-test restoration: If the fixture was removed, or if the nut was loosened, then the fixture and/or nut shall be restored to their pre-test condition in accordance with the following:

### Re-install the fixture (if it was removed).

### Clean the threads of the anchor projection and nut.

### Re-install the nut, tightening it to finger tight.

### Re-apply the prescribed installation torque (PIT).

### Re-perform testing (i.e., torque/proof-load method).

1. Testing Frequency

Unless otherwise specified, the following test frequencies shall apply:

1. Randomly select and test 10% of the anchors in each group.
2. A group of anchors consists of a homogeneous population with respect to the anchors themselves and their installation conditions.
3. If the aforementioned criteria results in the number of anchors to be tested being less than one (1), a minimum of one (1) anchor shall be tested.
4. If the tested anchors can achieve/withstand the stipulated Torque-/Proof-load-method loads (and, as applicable, are acceptable per the Post-test-restoration provisions), and the concrete surrounding/beyond the anchors doesn’t break out, the other anchors in the group shall be considered satisfactory.
5. If a test anchor fails, 20% of the anchors in the respective group shall be tested. If another anchor fails, all remaining anchors in the group shall be tested. Tested anchors that exhibit a low torque value, as well as any other anchors in a given connection, shall be re-tightened no more than once in order to achieve the prescribed installation torque.
6. The testing and its results shall be documented in a Testing Record in accordance with the following Article “Documentation.”

# 3.9 DOCUMENTATION

## Installation Inspection Record

* 1. The Installation Inspection Record shall include, at a minimum, the requirements of Section 01 4000 *Quality Requirements*; the attributes listed in appended (herein) Table 1 and, for each attribute, indication of how each anchor fared (e.g., pass/fail, etc.). Also, for each “failed attribute,” provide details and an explanation.

## Test Record

1. The Test Record shall include, at a minimum, the requirements of Section 01 4000 *Quality Requirements*, and the following information:
	* 1. Complete anchor designation (per the PART 2 Article “Undercut Anchor”).
		2. General location of anchor and description of group represented.
		3. Method of testing.
			1. If/when the proof-load method is used, the Testing Record shall include the information listed herein, as well as that listed in the Report section of ASTM E 3121.
		4. Test results (i.e., acceptable/satisfactory or failed/rejected).
		5. Names of inspector and installer (if two different people).
		6. Date of test.
		7. For anchors that failed/were rejected, location of anchor and type of failure/reason for rejection.

# 3.10 REWORK AND ABANDONMENT OF ANCHORS, AND REPAIR

1. When an anchor(s) doesn’t meet the inspection criteria applicable during or after installation, or the testing criteria stipulated the previous Article, “Inspection and Testing,” remediation shall include whichever of the following two (2) options applies. And such anchors shall be retested afterward:
2. Failure due to concrete breakout:
3. Remove the concrete debris and concrete damaged by the failure.
4. If the integrity of the concrete surrounding/beyond the damaged concrete is intact, it’s likely a replacement anchor can be installed in the same location (after repair of the damaged concrete).
5. Prior to repairing the concrete, contact the LANL STR for evaluation of the damage and approval of the proposed repair (HOLD POINT).
6. Replacement anchor shall have an embedment depth of at least two (2) diameters or three (3) inches, whichever is greater, beyond the depth of the damaged concrete. If the depth of concrete won’t allow for this embedment depth, the LANL STR shall be contacted for an alternative (HOLD POINT).
7. Failure due to anchor breakage, slippage, or loosening; or due to inadequate anchor embedment or installation\*:

\* NOTE: What follows is also applicable to an anchor that has been bent.

1. Fully remove the anchor.\*

\* NOTE: Per the Hilti catalog, a “Product Feature” of the HDA is that it’s “fully removable.” However, an HDA that’s been removed can’t be re-used.

1. If the integrity of concrete surrounding/beyond the defective anchor is intact, the installation of a replacement anchor in the same location (after the hole is re-drilled) might be possible.

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With regard to the following subparagraph, determination of the replacement anchor can vary from being straightforward to being challenging. On the one hand, in most instances, using an anchor one size larger**\*** than the failed anchor will suffice “on paper;” on the other hand, in practice, given the relatively limited selection of HDAs for use in nuclear applications, choosing a replacement anchor could prove to be “a handful.”

**\***Per Hilti, in *BOTH* diameter *AND* embed depth.

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1. Prior to re-drilling the hole, contact the LANL STR for evaluation of the failure, removed-anchor location, and determination of the replacement anchor (HOLD POINT).
2. If the location of the failed anchor can’t be re-used (due to inadequate concrete depth or integrity), grout the existing hole with a non-shrink grout specified in Section 03 6021, *Grouting* – *High-Confidence*, and relocate the replacement anchor in accordance with the minimum center-to-center spacing between a new hole and an unused hole stipulated in the prior Article “Installation of Anchors.”\*

\* NOTE: The Paragraph in “Installation of Anchors” that includes the minimum spacing referred to here also includes a waiver. That waiver is applicable here too (if the conditions associated with it are met).

* + - 1. If another relocation (i.e., subsequent to that described above) is believed to be necessary, prior to proceeding, obtain written permission from the LANL STR (HOLD POINT).
1. Mislocated anchors, or anchors installed for temporary purposes, need not be removed if they do not interfere with project-related work (e.g., subsequent anchor or fixture installations, etc.), pose a safety hazard to personnel, or are not “aesthetically offending.” Unremoved mislocated anchors shall be cut off flush with the concrete surface.
2. Mislocated anchors, or anchors installed for temporary purposes, shall be fully removed, and the resulting hole shall be filled with a non-shrink grout specified in Section 03 6021, *Grouting* – *High-Confidence*.
	1. Exception to full-removal requirement: Anchors that will be covered by a fixture may be cut off flush with the concrete surface.

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Regarding the following “trimming paragraph,” although removing excess projection does not affect the structural integrity of undercut anchors, in the case of the HDA, it will result in the loss of the length-indicator/head-marking.

The reason for requiring a thread projection after trimming is to ensure full nut-thread engagement (that’s clearly visible to, for example, an inspector).

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1. After installation is complete, the portion of the anchor projection that extends beyond the nut may be trimmed per the following stipulations. The projection before trimming and the length trimmed must be recorded on the inspection record.\* The projection after trimming shall not be less than one (1) thread beyond the top of the nut. All trimming must be saw-cut, and the trimmed area shall be painted if the anchor is outdoors, or in wet or corrosive area/ environment.

\* NOTE 1: The projection before trimming is the distance from the tip of the exposed end of the anchor to concrete surface.

NOTE 2: Trimming will result in the loss of the head marking (i.e., length indicator).

1. Concrete surface repairs: Repair concrete surfaces that haven’t been previously addressed herein, and have been damaged as a result of the work/project, using a non-shrink grout specified in Section 03 6021, *Grouting* – *High-Confidence*. Repaired surfaces shall be touched up with floor-surface paint acceptable to LANL STR (WITNESS POINT).
2. Locally spalled areas not more than 1/4” away from an anchor, and not more than 3/4” depth and 3/4” width, are considered undamaged and do not require repair.
3. Areas less than two (2) square inches, and not exceeding a nominal depth of 1/4”, are considered undamaged and do not require repair provided that they do not intersect/overlap with item 1 (above).
4. If the area exceeds 20 square inches, or if the nominal depth exceeds 3/4”, contact the LANL STR for evaluation of the damage and approval of the proposed repair (HOLD POINT).

END OF MAIN BODY OF SECTION

Appended (one page each): Figure 1

 Table 1

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Do not delete the following reference information:

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THE FOLLOWING STATEMENT IS FOR LANL USE ONLY

This Project-specific section is based on LANL Master Specification Section 05 0521 Rev. 2, dated August 28, 2018.

Figure 1

DRILLING HOLES IN CONCRETE AND MODIFYING BASEPLATES



|  |  |
| --- | --- |
| **BOLT DIA.A** | **MIN.EDGE DIST.B** |
| 1/4 " | 7/8” |
| 3/8 " | 7/8” |
| 1/2" | 1-1/8” |
| 5/8” | 1-1/4” |
| 3/4” | 1-1/2” |
| 7/8” | 1-3/4” |
| 1” | 1-3/4” |
| 1-1/4” | 2-1/4” |
| 1-3/8” | 2-1/2” |
| 2” | 3-1/2” |

Table 1

Required Inspection Attributes

The table’s “Source” column indicates where attribute details are located in this Section (i.e., PART 1, 2 or 3; Article title). Some Article titles are abbreviated following initial use. The “Other” column includes additional attribute details/information or the location of attribute details not found in this Section.

|  |  |  |
| --- | --- | --- |
| **Attribute** | **Source**  | **Other**  |
| 1 | Complete anchor designation (P) | 2, Undercut Anchor |  |
| 2 | Anchor lot number (P) | 2, Undercut Anchor |  |
| 3 | Number of anchors to be installed (P)  |  | Project Drawings |
| 4 | Concrete condition (sound) (P) | 3, General | Integrity intact[[1]](#footnote-1) |
| 5 | Concrete type (normal-weight) (P) |  | Project Drawings |
| 6 | Minimum concrete compressive strength (P) |  | Project Drawings |
| 7 | Concrete thickness (P) | 3, Drilling of Holes |  |
| 8 | Minimum anchor spacing(s) (P) | 3, Gen[[2]](#footnote-2) | Project Drawings |
| 9 | Minimum anchor edge distance(s) (P) | 3, Gen | Project Drawings |
| 10 | Drill and/or drill bit type, size, power, etc. (P) | 3, Preparation | MPII |
| 11 | Rebar cutting (D) | 3, Prep |  |
| 12 | Drilled hole cleaning (D) | 3, Prep and Drilling |  |
| 13 | Drilled hole dimensions (D) | 3, Drilling | MPII |
| 14 | Anchor condition (embedded portion not bent ) (D) | 3, Gen and Installation of Anchors |  |
| 15 | Anchor embedment depth[[3]](#footnote-3) (D) | 3, Drilling | Project Drawings |
| 16 | Setting duration (time, seconds) (D) |  | MPII |
| 17 | Red ring visible (D) |  | MPII |
| 18 | Anchor sleeve position relative to concrete/fixture (D) |  | MPII |
| 19 | Washer installation (D) | 3, Installation |  |
| 20 | Prescribed installation torque (D) |  | MPII |
| 21 | Anchor condition (perpendicular and projection not bent) (A) | 3, Gen and Install.  |  |
| 22 | Full nut-thread engagement (A) | 3, Gen |  |

LEGEND: P = Inspect prior to anchor installation (AI), D = Inspected during AI, A = Inspect after AI,

 MPII = Manufacturer’s Printed Installation Instructions.

1. If any of the provisions requiring the integrity of the concrete to be intact in the PART 3 Article “Rework and Abandonment of Anchors, and Repair,” apply then this “concrete condition” shall be inspected (for). [↑](#footnote-ref-1)
2. This reference is to the portion of the Article “General” that stipulates the min. spacing between newly-installed anchors in newly-drilled concrete (in/by the project). The same holds for min. anchor spacing indicated on project drawings. However, if any of the subsequent PART-3 provisions pertaining to min. spacing (e.g., between a new anchor/hole and an existing anchor/exploratory/unused hole, etc.) apply then they shall (also) be inspected. [↑](#footnote-ref-2)
3. This reference is to the Article “Drilling of Holes” since compliance with it ensures newly-installed anchors in newly-drilled concrete (in/by the project) will achieve the min. embedment depth stipulated on project drawings. However, if any of the subsequent PART-3 articles that include embedment-depth requirements (e.g., Installation of Anchors; Rework and Abandonment of Anchors, and Repair, etc.) apply then they shall (also) be inspected. [↑](#footnote-ref-3)