Manufactured Housing Institute

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Regulations Division
Office of General Counsel
Room 10276
Department of Housing and Urban Development
451 Seventh Street, SW
Washington, DC 20410-0500

Re: Docket No. FR-4928-P-01; HUD-2005-0006
RIN Number 2502-AI25
Model Manufactured Home Installation Standards

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Introduction

The Manufactured Housing Institute (MHI) respectfully submits comments in response to the proposed rulemaking noticed in the ***Federal Register*** of April 26, 2005, (70 FR 21497 – 21559).

MHI is a non-profit national trade association representing all segments of the manufactured housing industry, including: manufactured home producers; material and service suppliers; retailers; community developers, owners and managers; insurers; and, financial service providers. MHI manufacturer members produce over 83 percent of the HUD-Code manufactured homes built in the United States each year. MHI's community owner members manage land-lease communities, which house approximately 40 percent of the 22 million people who reside in over 10 million manufactured homes across the country. In addition, MHI's membership includes every State manufactured housing association across the nation. The State associations represent manufacturers, communities, retailers, installers and finance corporations.

General Comments

The Manufactured Housing Consensus Committee (MHCC) was the organization that provided the department with a draft model installation standard on December 18, 2003. The MHCC was directed by the Manufactured Housing Improvement Act of 2000 [MHIA, section 605(b)(1)] to perform this activity as part of the department's development of a comprehensive installation program for the entire country.

Under the MHIA, there are three basic components for the comprehensive installation program. These are: 1) development of a model installation standard [MHIA, sections 605(a) and 605(c)(3)(A)]; 2) training and licensing/certification of manufactured home installers [MHIA, Section 605(c)(3)(B)]; and 3) inspections of the installation of manufactured homes [MHIA, section 605(c)(3)(C)]. The last two aspects of the comprehensive installation program are subject to different rulemaking and no further comments will be provided.

Throughout its development of the draft model installation standard, the MHCC used the MHIA's three elemental principles to serve as the foundation for its draft document. These are that the model

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installation standard would: 1) serve as the model installation standard that a state-based installation standard must meet or exceed; 2) serve as the model installation standard that a manufacturer's installation instructions for each home must meet or exceed; and 3) serve as the installation standards for installing homes in states where HUD is responsible for operating a comprehensive installation program because the state has elected not to do so.

Upon HUD publishing its proposed rule on April 26th, two highly contentious and extremely important issues became readily apparent. These issues were in direct opposition to the MHI established positions taken during the MHCC development of its draft model installation standard document for HUD consideration. These two issues involve the underlying circumstances of how the installation program will codified and be updated in future years to come, and how HUD will intend to define/enforce the HUD model installation standard in default states.

Model Manufactured Home Installation Standard @ 24 CFR 3285

MHI asserts strongly that the federal model installation standard should not be codified under 24 CFR 3285, but instead should become subpart of 24 CFR 3280. By codifying the installation standard under Part 3285, the MHCC will not be privy and involved (120-day comment period prior to publication) with any proposed change by HUD in the future. The MHCC is the entity Congress specifically assigned to develop the installation standard and MHI is certain that Congress fully intended for the MHCC to be directly involved in its continued maintenance and updating. As currently proposed, HUD has to only provide the MHCC review period for construction and safety standards. In the definition for manufactured home (page 21520), HUD has embraced the fact that Part 3285 is for installation standards and Part 3280 is construction and safety standards.

Construction/assembly of the home and installation of the home go hand-in-hand. There should be no distinction in the federal regulations at 24 CFR 3280. This is similar to other private sector building codes where the code contains the design and construction requirements for the residential home in addition to any installation criteria that must be followed to complete the home. There should be no differentiation in the federal manufactured housing program between construction/assembly and installation. HUD will provide oversight for both components, so two separate documents (regulations) are not necessary for construction and installation.

Under the current 24 CFR 3282.14, the Alternate Construction (AC) process, as an extension of installation at the site, is used to ascertain that home installation conforms to local governing building code practices if the home, when completed, does not conform to the HUD Code. With respect to the model installation standard, this same process occurs with the only difference being that the home will conform to the HUD Code and its companion model installation standard once installed at the installation site. It seems illogical to have the federal mandate for homes not complying with the HUD Code to meet federal enforcement criteria and have homes that comply with the federal installation program outside of the either the current construction (Part 3280) or enforcement regulations (Part 3282).

HUD Enforcement in Default States

On page 21500, the proposed rule describes, for the first time, what a default state will be under the installation program. Under the MHIA §623(c)(11), states have a 5-year window of opportunity to develop and implement their own state installation program through state legislature. If a state determines that they neither have the manpower or the money to sustain a complete state installation program, then the state can cede its authority over to HUD, thus becoming a "default state". Essentially, a state has given up its right to establish and implement its own installation program.

HUD intends to permit a state or municipality to establish more stringent requirements for the installation of HUD Code homes, as long as they meet/exceed the model standard. Any default state should be preempted from establishing more stringent requirements over and above what the model installation

standard provides. States had a 5-year period beginning December 28, 2000 to enact an installation program that includes an installation standard. HUD would now permit any state or municipality to disregard the MHIA's provisions, wait and implement whatever they desire after the 5-year period ends, and circumvent the MHIA's requirements.

This essentially would permit "local jurisdictions" to enforce more stringent requirements for home installation over and above what HUD would enforce as the minimum requirements for default states. This could possibly be a way for local jurisdictions to "zone out" HUD Code homes in certain areas under their realm if they make installation requirements unreasonable for the community owner or individual tenant/homeowner to bear the initial cost. HUD's default state installation standard should be preemptive, similar to its status on design and construction of homes under 24 CFR 3280.

Technical Concerns

There are a variety of technical concerns that MHI brings forward for comment. Some concerns arise because HUD has revised the original intent of the MHCC December 2003 draft standard or established new requirements for the initial placement of new manufactured homes. These concerns are listed in two separate categories entitled Critical and Important Issues. Under each section, there is no attempt to provide any priority of importance except that these issues have been raised through MHI's review and comments received from its membership.

HUD has solicited response by a number of questions relating to the model standard's content and the extent of its enforcement measures. Page number(s) will be referenced throughout along with actual section references where MHI's comments apply.

1. Critical Issues

- **Mortared Pier Configurations [page 21528-21529; 3285.306(b)-(c)]**
  These sections for pier configurations over 36 inches in height require a mortared assembly unless otherwise specified in the manufacturer's instructions. This is completely opposite of what was submitted by the MHCC. The MHCC stated that mortar is not required for double-stacked piers unless required by the manufacturer. This requirement could conceivably cause unnecessary mortared piers if the manufacturer's manual is silent on this installation aspect, and the model installation standard required mortar in all instances. This same concern also applies to one caption in Figure B to §3285.306.

  In all likelihood, a pier greater than 80" in height will require a mortared assembly. However, that is something that may not be in the manufacturer's instructions since a registered design professional (PE) can determine support system design. The last sentence of this section should be deleted as it serves no useful purpose and the PE design will specify whether mortar is required or not.

- **Placement of Footings in Freezing Climates [pages 21502, 21510 and 21512; 3285.312(c)]**
  The MHCC draft model installation standard included insulated foundations as a method to not have pier footings extend to the frost line depth. This can be found in the MHCC draft model standard at Section 6.3.2.3. The basic intent was to include insulated skirtings as an insulated foundation system, thus the reason the MHCC draft included a provision for cross-ventilation of the space under the home. In the proposed rule at §3285.312(c)(3), this statement was deleted and replaced with any system must be designed by a registered PE **and** conform to ASCE 32. This mandatory reference to ASCE 32 may effectively eliminate any type of insulated skirting system from being used to permit pier footings to be above the frost line.

  By requiring a PE design (acceptable), and to make any system subject to ASCE 32 requirements (not acceptable), essentially eliminates insulated skirting materials from ever being used. ASCE

32 is for foundation systems composed of a basement, a slab, or a crawl space with a perimeter foundation wall. Insulated skirtings, with typical piers and footings, may not be applicable to ASCE 32. There is no problem with ASCE 32 being used as an **optional** reference standard, but HUD made it mandatory in all instances, thus requiring a permanent-type foundation for every home should you not want to go to frost depth with pier footings.

Also, if using §3285.312(c)(2), for slab systems, ASCE 32 is also required for conformance. ASCE 32 will require vertical and horizontal insulation materials below grade. Many MHI members do insulate floating slab systems in freezing climates but the affect of the more stringent ASCE 32 requirement needs to be addressed.

Under §3285.404, it is possible for ground anchors not to be installed below frost line. The model standard permits footings to be located above frost line by §3285.312(c). One can use a floating slab or insulated foundation system and have footings above frost line. If the footings which bear the vertical loads can be above frost line, then why would the anchoring system not be able to do the same? The longest ground anchor produced is 6 feet long, and in many areas of the country, it may be next to impossible to install then in all soil classifications. There should be a reference to §3285.312(c), in which the approved alternate anchoring system may be included as part of a foundation support system (floating slab or insulated foundation).

Footnote 1 of 3285.310 Figure A requires all footings to extend below frost depth. This is contradictory to §3285.312(c), where insulated foundation systems may permit footings at grade in frost areas. The footnote should reference section §3285.312(c) for footing depths. This same comment also applies to Figure B.

There have been tests/reports performed on frost protected foundations for HUD Code homes and skirting materials. The reports referenced at Enclosure I are attached to this letter for departmental review in determining whether it is necessary for all foundation systems in freezing climates to require conformance to ASCE 32.

.1 Manufactured Home Foundations Design for Seasonally Frozen Ground, Progressive Engineering, Incorporated (PEI), Goshen, IN, June 14, 1996.
2. OH MHA: Manufactured Home Movement – Lancaster, OH, PEI, July 2000 – 2001.
3. OH MHA: Manufactured Home Movement – Circleville, OH, PEI, November 2000 – 2001.
4. OH MHA: Manufactured Home Movement – Circleville, OH, PEI, September 2000 – 2001.

As an alternative to making ASCE 32 an optional reference standard or revising §3285.312(c) to the original MHCC language submitted on December 2003, MHI would offer the following performance-based language as a substitute, "Footings placed in freezing climates must be designed and installed using methods and practices that prevent the effects of frost heave in accordance with the manufactured home design and the requirements of the Manufactured Home Construction and Safety Standards (Part 3280)."

- **Permanent Foundation Systems [21502, 21509 and 21511; 3285.314(a)]**
Section 3285.314 should state what is being referred to under this section. The described text of the proposed rule seems to be more in line with §3285.314(b). The first two sentences of this section are mainly commentary and provide no information on how or what to use when designing permanent foundation support systems for HUD Code homes. They should be deleted in their entirety. The first is in conflict with HUD's preemption for default states to not require more stringent requirements than that contained in the model standard. The model standard should make no mention of anything concerning how mortgage lenders or others can establish financing eligibility requirements for permanent foundations. This is for the financial institutions to decide and this standard needs to stay focused on the MHIA's premise, to provide a **model installation standard**. Financing options for the model standard are outside the scope of the

MHIA and should be deleted.

The original MHCC recommendation stated the obvious. "Designs for permanent foundations (such as basements, crawl spaces, or load-bearing perimeter foundations) may be permitted to be obtained from the home manufacturer, or designed by a registered professional engineer or architect, and constructed in accordance with local building code requirements". This is the proper performance-based language for any section on permanent foundations.

Should the department still not finalize the MHCC language, below is performance-based language that can be used as an alternate, "The placement of a manufactured home on a permanent foundation must be in accordance with the state requirements, installed in accordance with their listing by a nationally recognized testing agency based on nationally recognized test protocol, or installation in accordance with the manufacturer's approved permanent foundation installation instructions; and in all cases based on the home's design and the load requirements of the Manufactured Home Construction and Safety Standards (Part 3280)." This is performance-based language that the MHCC developed at its May 25, 2005 conference call. MHI aggress with this type of performance language if the original MHCC language submitted in December 2003 is not appropriate for federal regulations.

Permanent foundation requirements would be specific to the installation site in question, see page 21509. With an approved state-based installation program, the LAHJ will require the permanent foundation systems to meet the local governing building codes. This has been the case for years and there is no compelling reason to change the current path. HUD's enforcement of an installation program in default states should provide the same. The MHCC draft provided the mechanism to cover this topic. It stated that when a permanent foundation system is contemplated, the design would need to follow accepted engineering practice, be designed by the manufacturer or professional engineer, and in conformance with local governing building codes. This would seem appropriate to re-insert this language in §3285.314 to alleviate the concern.

It is not appropriate for the model (minimum) standard to require that manufacturers provide DAPIA-approved designs for permanent foundations, see page 21509. This should be an option to the homeowner, if they so choose, but the manufacturer should only need to provide the design when selected. MHI has encouraged manufacturers to provide permanent foundations designs for homes and it is hoped that the model standard will do the same. But to make it mandatory in every instance is overkill, especially when a large majority of HUD Code homes will follow the conventional installation method of piers with ground anchor assemblies. There are many smaller manufactured home producers that do not have engineering staff available to perform this task. These companies use outside engineering consultants to provide their design packages. This would be an added extra cost to these small producers for complying with a requirement that their buyers may not even wish to consider.

- **Ground Anchoring Assembly Corrosion Protection Requirements [page 21512; 3285.402]** HUD modified the MHCC draft standard with regard to galvanizing of ground anchors, anchor equipment and stabilizing plates. First of all, this section requires ground anchors to be zinc-coated in all instances. This deviates from the HUD Code in that it requires anchoring equipment to have a resistance to weather deterioration at least equivalent to that provided by a coating of zinc on steel of not less than 0.30 oz/ft^2. This would preclude other forms of known corrosion protection from being used in lieu of galvanized anchors. Stainless steel, epoxy coatings, and even mill galvanizing are acceptable methods of corrosion protection in the site-building industry.

Secondly, the problem is that imported (foreign) anchors are less expensive than USA-made ground anchors with the same type of zinc galvanizing. Has the economics of requiring all zinc-coated anchors been identified? MHI member product suppliers say this passage would require ground anchors to be more expensive than their foreign counterparts.

Thirdly, not all ground anchor assemblies will require steel stabilizer plates, see §3285.402(b)(3)(ii). If a ground anchor assembly is tested to be listed or certified by the current MHCC Subcommittee/Installation ground anchor test protocol under consideration, *uses an ABS stabilizer plate*, and passes all failure criteria for a certain soil classification, can that listed or certified anchor assembly be used under this section?

- **All Hinged Roofs to be Applicable [page 21504 and 21512; 3285.801(f)]**
  Hinged roofs are not subject to AC letters or On-Site Completion when only in Wind Zone I, limited to a 7:12 roof pitch and cannot have any flue penetration above the hinge. The model standard should be extended to cover any hinged roof regardless of wind zone, roof pitch or flue penetration. This is a normal construction sequence that is occurring more and more frequently for HUD Code home installations.

  The manufacturer can provide installation instructions for hinged roofs that conform to the HUD Code. These instructions would require DAPIA approval. This is no different than providing installation instructions for marriage line/crossover connections, alternate ground anchor assembly spacing that meets/exceeds the model installation standard, or close-up details for multi-section homes.

  This option of placing hinged roofs under the model installation standard would save considerable money with regard to IPIA inspection under the on-site completion rule, and considerable time under the AC letter process. This is not a new form of HUD Code assembly and it has been performed for years. Time has shown that industry can treat hinged roofs as installation set-up without departmental oversight.

  On page 21504, this same suggestion for the model standard to cover all hinged roof applications is referenced. A hinged roof should be treated as construction of the home's roof assembly and subject to the requirements of the HUD Code. Once these hinged roofs are placed, they would have to conform to the HUD Code. This would be evident for hinged roofs in all Wind Zones, and not just Wind Zone I as HUD has specified in the proposed rule. As long as a hinged roof, in any Wind Zone, under any condition complies with the HUD Code after installation, it should not be subject to either on-site completion or an AC letter. If the hinged roof after installation fails to meet the HUD Code, then AC letters should be required.

- **Model Standard Should Include the Pocket Penetrometer [page 21508; 3285.202]**
  The various methods to determine soil bearing capacity and classification have been deleted in lieu of accepted engineering practice. One such method, the pocket penetrometer, is a common method to determine soil bearing capacity. It also is accepted in many states throughout the country as an appropriate method. It seems reasonable to permit the LAHJ to accept any method they feel is adequate. Therefore, it is suggested that §3285.202(a)(1) be modified to permit the LAHJ to accept any method as follows: "*Soil tests*. Soil tests that are in accordance with generally accepted engineering practice; <u>a pocket penetrometer or other method acceptable to the LAHJ</u>; or".

- **Ground Anchor Test Protocol [page 21503; 3285.402(c)]**
  The MHCC Subcommittee/Installation is presently developing a test protocol for ground anchor assemblies. MHI believes that this is the appropriate group to take on the development of test protocol. HUD should wait until the MHCC has submitted their version of a ground anchor assembly test protocol before any attempts to develop one outside the MHCC or provide specific requirements for testing in the model standard.

- **Proprietary Foundation System Test Protocol [page 21501 and 21509]**
  The MHCC Subcommittee/Installation is presently developing a test protocol for ground anchor assemblies. MHI believes that this is the appropriate group to take on the development of test

protocol for proprietary foundation support systems. Until one can be developed and approved by HUD, industry should continue on its present track of having these systems approved by states with qualifying installation programs or HUD in default states using the same criteria that are being used to approve these systems at present. DAPIA approval would provide one method of approval since manufacturers may wish to include some type proprietary foundation system in their installation manuals.

The MHCC has been targeted to develop a test protocol for proprietary foundation systems, once the ground anchor assembly test protocol has been completed. There have already been two proposals submitted to the MHCC for the test criteria (by a Subcommittee/Installation member). It would be best to delay providing any specific design considerations for proprietary systems in the proposed rule at this time. The model standard is the minimum acceptable requirements and the possible alternate foundation system requirement inclusion goes beyond the MHCC "one method of installation" principle.

Any proprietary system can be evaluated by the manufacturer. If they so choose, they could elect to include any proprietary foundation system in the installation manual. If so, then DAPIA approval would be required. Ultimately, any alternate construction method or design should be approved by the state in accordance with local governing building codes or HUD in default states per the HUD Code.

It would be up to each state to determine the appropriate inspection level for proprietary foundation systems. By the MHIA, a state only has to perform inspection but no frequency is specified. A state could always require every proprietary system to be inspected, but it is there right to do it under the MHIA's premise. In default states, if HUD requires 100 percent inspection of home installations, every proprietary system would be inspected.

- **Complete Home Installation and Close-Up Assembly [page 21499 and 21500]**
  The MHCC encouraged the inclusion of close-up activities in developing its draft model standard. The main emphasis was to provide the installer of the home with all the necessary information they would need to complete the home. The department has dwelled on the fact that inspection of the close-up activities will be required in all instances. However, that is not necessarily the case, especially for those states that have a self-certified installation program. In states enforcing their own installation program, they may not require 100 percent inspection for home installations. They may only require 50 percent or below, which is their right under the MHIA §605(c)(3)(C). The MHIA only states that inspection must be performed for a qualified state inspection program but it is silent on the frequency of inspections. In a default state that is administered by the department, 100 percent inspections of close-up activities could be required depending on what frequency of inspection will be required in default states under the remaining portion of the installation program.

  How can the manufacturer be responsible for close-up work when the person installing the home may not be under contract with or under the supervision of that particular manufacturer? Manufacturers can only control the close-up activity when they use their own set-up crews to install homes (as some do). However, to make the manufacturer responsible for every one of their home's installations is not practical or possible without an extraordinary expense to hire third-party agencies to perform the inspections.

  Close-up should be a part of the installation of the home and the responsibility of the installer or in some cases the retailer. Thus, close-up becomes part of the installation process of home completion. In many instances, the manufacturer has no control or oversight over the installer when contracted under the home's retailer, so the onus should fall on who contracts with the installer to set the home.

MHI is not certain how many states perform close-up inspections. Based on a survey of our membership to determine how states are complying with the MHIA, only 27 states have responded positively towards any type of inspection. However, the magnitude of the inspection is not indicated in some instances.

Requiring close-up inspections would add cost to the overall inspection process because it is doubtful that one inspection for the setting of the home, and additional inspection for close-up, could be completed at the same time. If some states have not had problems with home close-ups, then why should the model standard require it as a minimum? This is to be a minimum standard for installing the home, not a maximum. States should be encouraged to inspect close-ups, but it should not be a condition of acceptance of any state installation program. The MHIA does not specify the type of inspection that must be performed, only that inspection is provided. This could be the start of a laundry list of inspections the departments feels is necessary to properly install the home. It should be up to each individual state to determine what they deem necessary for proper installation of the home.

A basic premise under the proposed rule is that manufacturers' installation instructions must meet/exceed the model standard. The instructions cannot take the home out of compliance with the HUD Code and must provide adequate instructions to properly complete the home. However, the MHIA is intended to provide relief from the most common complaints known to industry, improper set-up of the home. This is responsible for a majority of complaints that retailers and manufacturers receive. This is what the installation program is all about, to ensure the adequate installation of the home, or in other words, to be absolutely sure the installer has installed the home according to the manufacturer's installation instructions, or whatever requirements may apply. That is why the onus of complying with the model standard should fall onto the installer's shoulders. It is also why other parts of the installation program are specifically geared towards improving the training and licensing/certification of installers, see MHIA §605(c)(3)(B).

- **Implementation of Seismic Criteria [page 21500]**
  The model standard should maintain the status quo with respect to any seismic safety criteria. As stated in the proposed rule, some states already are implementing seismic requirements for the installation of HUD Code homes. And this is how it should be. If a state wants to provide for seismic design or construction concerns specific to the foundation support system, then they should enact requirements through state legislation when attempting to implement a state installation program. In this manner, any state program would equal/exceed the HUD model standard with respect to foundation support system design. The model standard should be the minimum necessary requirements to properly install the home. Adding seismic criteria to the model standard might conflict with what some states are presently mandating that are working sufficiently. Since there are no HUD Code requirements for the home itself to consider seismic design, why should the model standard, as a baseline document, do otherwise?

2. **Important Issues**

- **Figures/Tables for Marriage Line Pier Supports [page 21510; 3285.310]**
  The easiest manner to provide for the appropriate location and spacing of piers would be to reference the manufacturer's installation manual. However, HUD has mentioned several times about this type of circular reference being outside of the model standard's scope. Since each new home would have its own installation manual, these types of requirements would be provided in every instance, but they are model-specific. In addition, state-based installation standards may set their own requirements which may conflict with the minimum model standard. However, HUD will judge whether a state-based installation standard meets/exceeds the model standard, and HUD will use the model standard in default states. In any event, some minimum guidance should be given to installers and the existing figures represent the MHCC's attempt to provide that guidance.

- **ABS Stabilizer Plates [page 21512;3285.402(b)(3)(ii)]**
  Not all ground anchor assemblies will require steel stabilizer plates. If a ground anchor is tested and listed/certified by the current ground anchor test protocol under consideration, *uses an ABS stabilizer plate*, and passes all failure criteria for a certain soil classification, can that listed or certified anchor assembly be used under this section?

- **Alternate Design Requirements [page 21501, 21509 and 21511 – 21512]**
  The model standard appears to include the necessary design assumptions used to develop the tables and charts for piers, footings and anchor spacing requirements, see page 21501. Almost all design assumptions are covered by existing footnotes to the tables and charts. It might be worthwhile to consider supporting a concept to include a section within the model standard, where applicable, to list the design assumptions for such items as footings, piers and ground anchor spacing requirements. In this manner, the design assumptions would not be overlooked.

  It is not entirely clear that manufacturers, or any other registered PE, may perform alternate designs as long as they meet or exceed the design assumptions provided in the model standard. While HUD states numerous times throughout the proposed rule (pages 21509 and 21511 – 21512) that the intent is provided, <u>it would be advantageous to provide a section in the model standard under §3285.1 to specifically permit alternate materials and methods of construction</u> that are not covered in the model standard to be used as long as the intended option conforms to the minimum requirements (design assumptions) included in the model standard, or even the HUD Code, which may apply in some instances.

  The MHCC draft model standard was not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed in a model standard, provided such alternative had been approved by either the LAHJ or HUD contractor (in default states). If the alternate design satisfactorily meets or exceeds the model standard requirements, then why should it not be permitted as an approved alternate method of construction to the one method prescribed in the model standard for anchoring against wind? This would assist manufacturers who may decide to include other methods of home support and anchorage in their installation manuals.

  I see no reason why the manufacturers cannot comply with the model standard for their installation manuals. The ultimate goal of the MHCC was to provide a document that manufacturers could use as the baseline for their own manuals. They also would be permitted to insert special instructions (for assemblies or techniques) to accomplish alternate materials, components or assemblies outside the model standard's minimum requirements.

  MHI was led to believe that the model standard could not have any appendices since they could be considered non-enforceable. This was a track the MHCC Subcommittee/Dispute Resolution, which while working on accessibility requirements for the HUD Code, was told appendices are not enforceable and any requirements would need to be included in the body of the code itself. Even if an appendix option were available, the prescriptive provisions in the tables for piers and ground anchor spacings need to be included in the body of the model standard for ease of use by the installer.

  It will be up to the DAPIA to approve that the manufacturers' installation manual meets/exceeds the model installation standard by the MHIA §605(a). Whether a manufacturer follows the model standard format or their own format should not matter to the department. The basic intent is to be sure the manufacturer's manual conforms at least to the minimum installation requirements stipulated by the model standard.

- **ABS Footing Pad Approval [page 21510; 3285.312(a)(3)]**
  ABS footing pads are currently being approved and used. With qualifying state-based programs,

the state should determine the appropriate criteria for ABS pad approval. MHI assumes ABS pads are tested for compressive strength as a minimum. Status quo with how these materials are presently being approved for use in home installation should be maintained until an actual nationally recognized material/testing standard is developed.

- **Flood Hazard Requirements [page 21520; 3285.101(d)(1)]**
  The two methods indicated in §3285.101(d)(1) for flood hazard requirements should not be all inclusive. In most instances, the LAHJ will have the final word and should be able to eliminate unnecessary flood hazard criteria that may not be required for other types of residential housing. Also, the option should exist for the LAHJ to enforce what they feel is necessary. It is their right if the state has self-certified its program through HUD. This section basically should provide two options for flood hazard criteria: 1) per the LAHJ; or 2) per the NFIP regulations. The manner presently written makes both all inclusive no matter what the circumstance.

- **Model-Specific Home Plans [page 21508; 3285.2 and 21511; 3285.403]**
  There is no need to require model-specific plan criteria for the model standard, see page 21508. If there are specialized criteria for a certain model home, then the manufacturer can provide that information in the installation manual that accompanies each new home. The model standard provides one method to install the home, whether it is footings/foundation support systems, ground anchor spacings, or utility crossovers/connections. Since the model standard is considered the minimum requirements, any specialized model home will contain the accompanying plans/specifications to complete the home installation. Thus, the DAPIA will already determine that the specialized manufacturer's manual has met or exceeded the model standard. Subpart G contains the minimum criteria necessary to complete the home.

  This proposed rule would require manufacturers to provide an installation manual for all homes, as the proposed rule applies to the initial installation of the new home, see page 21511. The manufacturer may have installation criteria listed in the manual for the specific model home. Therefore, the best alternative might be to permit the mating line anchorage/connection to be determined by the manufacturer's installation manual. The manufacturer's manual will need DAPIA approval to ensure that it meets/exceeds to federal model standard. Checks and balances are present for mating line anchorage mechanisms. The federal model standard is to be a "minimum" standard and some reliance on manufacturers' proprietary designs in their installation manuals is necessary. The model standard should not attempt to provide installation requirements for every conceivable multi-section home available for purchase.

- **Minor Tears in Vapor Retarder Materials [page 21501 and 21523; 3285.204(c)(3)]**
  It is true that excessive tears or voids can create additional moisture release into the space between the home's floor system and finished ground surface. This existing text is left open to differing interpretations no matter who is overseeing the installation program (HUD or SAA). What would be considered a minor tear (2", 6" or 12") considering the overall area of the vapor retarder underneath the home? How can this type of regulation be consistently enforced by states with their own installation program or various HUD contractors that enforce programs in default states? This is probably one instance where a prescriptive requirement would be necessary, but any such prescriptive requirement must be realistic.

- **Site Preparation [page 21506; 3285.2]**
  There is no reason to require a professional engineer or architect to be consulted for site preparation if the manufacturer's manual does not cover it. Every manual that has been reviewed by MHI always contains some information with regard to site preparation. If by chance a manual does not, then the LAHJ can be looked to for any conforming requirements. This could be an added cost burden to individual homeowners or community owners. Installers already must determine soil bearing capacity and classification that relates to selecting the appropriate footings, pier configurations and ground anchor spacing.

- **Manufacturers Installation Manual Standard Format [page 21501]**
  It will be up to the DAPIA to approve that the manufacturers' installation manual meets/exceeds the model installation standard by MHIA §605(a). Whether a manufacturer follows the model standard format or their own format should not matter to the department. The basic intent is to be sure the manufacturer's manual conforms at least to the minimum installation requirements stipulated by the model standard.

- **Manufactured Home Piers [page 21509; 3285.303]**
  The proposed rule already specifies that manufactured home piers, other than concrete masonry units or steel jack stands, be listed and labeled for the required vertical loads and appropriate lateral loads. This appears to be a performance-based requirement. There does not seem to be any reason to begin a laundry list of the design conditions. HUD should maintain status quo until some nationally recognized material/testing protocol can be developed.

- **Shim Use for Home Leveling Purposes [page 21509 and 21528; 3285.304(c)]**
  Items (1) through (3) are supposed to be independent of each other. The MHCC draft standard included "or" after each item so that they are optional requirements when it comes to using shims to fill gaps while leveling the home. The manner presented states that "any combination applies", but without the "or" between each item, it appears to make them all mandatory in every instance. One interpretation would be that if you use item (2), item (3) is also necessary since item (2) ends with "and" making both inclusive.

- **Steel Reinforcement for Footings [page 21502; 3285.312(b)(1)(ii)]**
  There is no need to provide steel reinforcement specifications for cast-in-place footings in the model standard. This will be determined by either the manufacture or registered PE for the intended application. The model standard is a minimum standard to install HUD Code homes. If anything, LAHJs will require reinforced footings based on local requirements if necessary. If the manufacturer desires to provide alternate footings designs, this would be the appropriate time to analyze whether reinforced footings are necessary for a specialized foundation support system for specific pier loads.

- **Site Preparation - Organic Material Removal [page 21508; 3285.201]**
  It may not always be necessary to remove of 6 inches of soil for placement of footings on undisturbed soil. The MHCC draft standard left this open to determine the extent of ground clearance for proper foundation support system set-up. Also, it is possible that manufacturer's manuals, or a state installation program, may require removal of a minimum thickness of soil for proper footing placement. This could present conflicts if the manual or state standard specify a thickness of organic material that does not meet or exceed the model standard. This issue is better left to LAHJ to decide.

- **Drainage of Water Runoff [page 21501]**
  The model standard requires any water runoff from gutters and downspouts to be diverted away from the home. The HUD Code or the model installation standard does not specifically require gutters or downspouts for installation on every HUD Code home. If the producer/retailer does provide gutters and downspouts as an additional feature for the home, then the installer must ensure that adequate drainage is provided at the site.

- **Moisture Build-Up Laundry List [page 21521; 3285.203(a)]**
  There is extra verbiage in this section that is not necessarily due to moisture build up under the home. These are the "dampness in the home, buckling of walls or floors and problems with the operation of doors and windows". Even though this is original MHCC language, is it really necessary to provide a laundry list of what might occur without proper drainage? These are sometimes caused by other means such as moisture infiltration through the home's envelope, by improper setting of the home, or inadequately prepared piers/footing. These examples have

nothing to with drainage under the home. It is best to adhere to what is usually evident rather than providing a descriptive laundry list.

- **Home Construction Items [page 21504]**
  The MHCC specifically did not address some of the items mentioned in the proposed rule (frame bonding, panel boxes and feeder requirements). These should be considered part of the HUD Code that would need plant inspection or listing/labeling to ensure compliance. Some of these items might be home model specific and it is best to leave these issues up to manufacturers to determine how best to provide proper design, construction and installation requirements. Some of these issues are not a "one size fits all" type of condition. The "minimum" model standard cannot be expected to cover every conceivable condition.

- **Bay Window Inclusion [page 21512]**
  The department has deleted the MHCC draft requirements for bay window installation under the model standard. Under §3285.801(f), the manufacturer would need to furnish installation instructions for the hinged roof so that the installer would know the necessary elements of field installation. Bay windows are in the same vein as they could fall under a "ship-loose" item. As long as the home is designed properly for the product attachment, the manufacturer provides DAPIA-approved installation instructions, and the installer can follow those instructions, bay windows should be covered under the model standard.

Criteria Considered Necessary for the Model Installation Standard

The model installation standard includes some criteria that are necessary (in MHI's view) for proper application and enforcement of the standard once final rulemaking is completed. The four issues highlighted below may not have been discussed by the MHCC when it developed its draft model standard for HUD's consideration. By the department suggesting their inclusion, the proposed rule would identify some important installation and enforcement criteria for providing the "minimum" requirements for 1) manufacturers' installation manuals; and, 2) state-based installation standards.

1. **Applicability [page 21505 and 21518; 3285.1(a)]**
   The proposed rule is applicable only to the initial installation of the new home. States could enact the model installation standard to apply to secondary moves if so desired. At present, the model standard covers only new installations and states are left open to determine what requirements are necessary for secondary moves. These requirements could take the form of enactment of criteria found in existing state installation standards or enactment of new installation standards through state law.

2. **Approval of Manuals and State Standards [page 21506 and 21518; 3285.1(a)(1) and 3285.2]**
   HUD identifies that all manufacturers' installation instructions will need to meet or exceed the model installation standard. DAPIAs will be responsible for determining whether a manufacturer's manual fulfills this requirement. When it comes to existing state-based installation standards, HUD will determine whether the state requirements meet or exceed the model installation standard through state self-certification.

3. **Installation Conforms to Data Plate [page 21520; 3285.102]**
   This will codify a regulation that spells out that one cannot install any manufactured home in a higher wind zone, snow load or thermal zone than the home's original design for its initial installation. MHI receives this question on occasion for used home sales. New §3285.102 can provide HUD guidance on future industry inquiries of this nature.

4. **Alterations [page 21500, 21506 and 21507; 3285.3]**
   Alterations appear to relate to additions to the home after sale that may affect the compliance of the home with the HUD Code. This could be interpreted to cover such additions as awnings,

carports, or attached garages. By the model standard stating that alterations cannot impart any load to the home unless the alteration is designed to do so, makes most of these types of alterations independent of the home itself, or self supporting. This would not permit a retailer to provide an attached carport or screened room/porch without consulting the manufacturer. Due to the Fall 2004 hurricane season in Florida, this would seem appropriate. This would curtail the practice of a retailer or community owner from attaching these add-on structures to the home without the manufacturer's knowledge and require an actual designed anchorage mechanism.

Conclusion

HUD should be applauded for publishing the proposed rule for development of the model manufactured home installation standard. While the department's proposed rule is largely based on the MHCC December 2003 draft model standard, MHI felt it necessary to bring to the agency's attention several concerns. Two of those extremely important concerns were addressed on pages 2 -3 (codification in the federal regulations and enforcement of the model standard in default states).

This model standard proposed rule is one part of a comprehensive installation program that a state could use as a basis to develop their own state-based installation program. With the timely publication through the rulemaking process of the other two parts of the program (training/licensing or certification of installers and inspection of home placements), some states, who have delayed any enactment of an installation program through state legislature, should be able to begin their approval process.

If there any questions concerning the above comments, MHI will be happy to address them with the department staff.

Sincerely,

Mark A. Nunn
Vice President – Technical Activities

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Attachment

/5

PE

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Manufactured Home Foundation Design for Seasonally Frozen Ground

for

Manufactured Housing Institute
2101 Wilson Blvd.
Suite 610
Arlington, VA 22201-3062

Final Report
June 14, 1996

by

Ned C. Myers, P.E.

ENCLOSURE I

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Preface

This report was prepared by Ned C. Myers, P.E., President of Progressive Engineering, Inc., 58640 State Road 15, Goshen, Indiana 46526. Funding for this work was provided by Manufactured Housing Institute, 2101 Wilson Blvd., Suite 610, Arlington, VA 22201-3062.

Introduction

Foundations in regions with seasonal ground frost penetration need to be designed to prevent movement due to frost heave.

A literature search was conducted to identify existing design methodology and determine whether physical tests had been performed to verify the methodology.

Physical frost penetration tests were also conducted by Progressive Engineering, Inc. in the winter of 1994-1995 on two (2) manufactured homes in Green Bay, Wisconsin. One home had standard skirting with vents open and the other had 1 inch of expanded polystyrene insulation behind standard skirting with vents closed off. Two (2) manufactured homes in Midland, Michigan were also instrumented for the winter of 1995-1996. One home had 1½" of extruded polystyrene behind the skirting with four (4) thermo vents and the other home had 2" of extruded polystyrene behind the skirting with a power vent on a humidistat.

The methodology and design proposals contained in this report are a combination of existing methodologies and information obtained from the test conducted by Progressive Engineering, Inc.

Background

Foundation design in areas of frost depends on the choice of an appropriate foundation depth and/or protection of the foundation from the effects of frost, particularly where there is frost-susceptible soil. Harmful frost action arises under certain conditions. Frost must penetrate down to frost-susceptible soil, and sufficient water must be available to feed ice lens formation and growth in this soil at an adequate rate. Ice lenses produce forces that are usually directed at right angles to the frost front. These forces can be very large and can lead to heaving of all or parts of the foundation as the soil freezes below. The magnitude of the heave forces cannot generally be determined, but they are related to the frost susceptibility of the soil and the availability of water. It is impractical to fully restrain heave, so one should design so that it does not take place at all. In practice this means that any frost-susceptible soil that can affect the foundation must be insulated so it will not freeze or that it must be replaced by non-frost-susceptible material and that water is prevented from being supplied to the freezing front.

Frost damage can also arise from "sidegrip" occasioned by the lateral shearing stress exerted by the freezing soil on adjacent foundations, such as foundation walls, strips, columns or posts. There is then a tendency for these to be lifted up by shearing forces acting along their side surfaces; this is counteracted by the weight of the foundation, by the load it carries, by anchorage below the frost line or by providing a very smooth-slick surface along the sides.

Frost Susceptibility

Clean coarse sands, gravel, and crushed stone are too coarse textured to promote the capillary transfer necessary to feed the growth of ice lenses, and are termed non-frost-susceptible. Silty soils and very fine sands, on the other hand, have high capillary conductivity and readily aid the growth of lenses. They are termed frost-susceptible soils. Pure clays promote capillary rise over large vertical distances, but their rate of moisture transfer is so slow that they tend to produce thin lenses with very little heaving. Under favorable conditions, however, clays can heave, and with much greater pressure than silts.

While there is engineering consensus about the characteristics that make soils clearly frost-susceptible and clearly non-frost-susceptible, there is no reliable method for predicting the borderline conditions except by laboratory or field testing. Small amounts of clay and silt can contaminate otherwise frost-free coarse-grained soils. In recognition of this, the simplest methods of classifying frost susceptibility is to relate it to the content of soil fines.

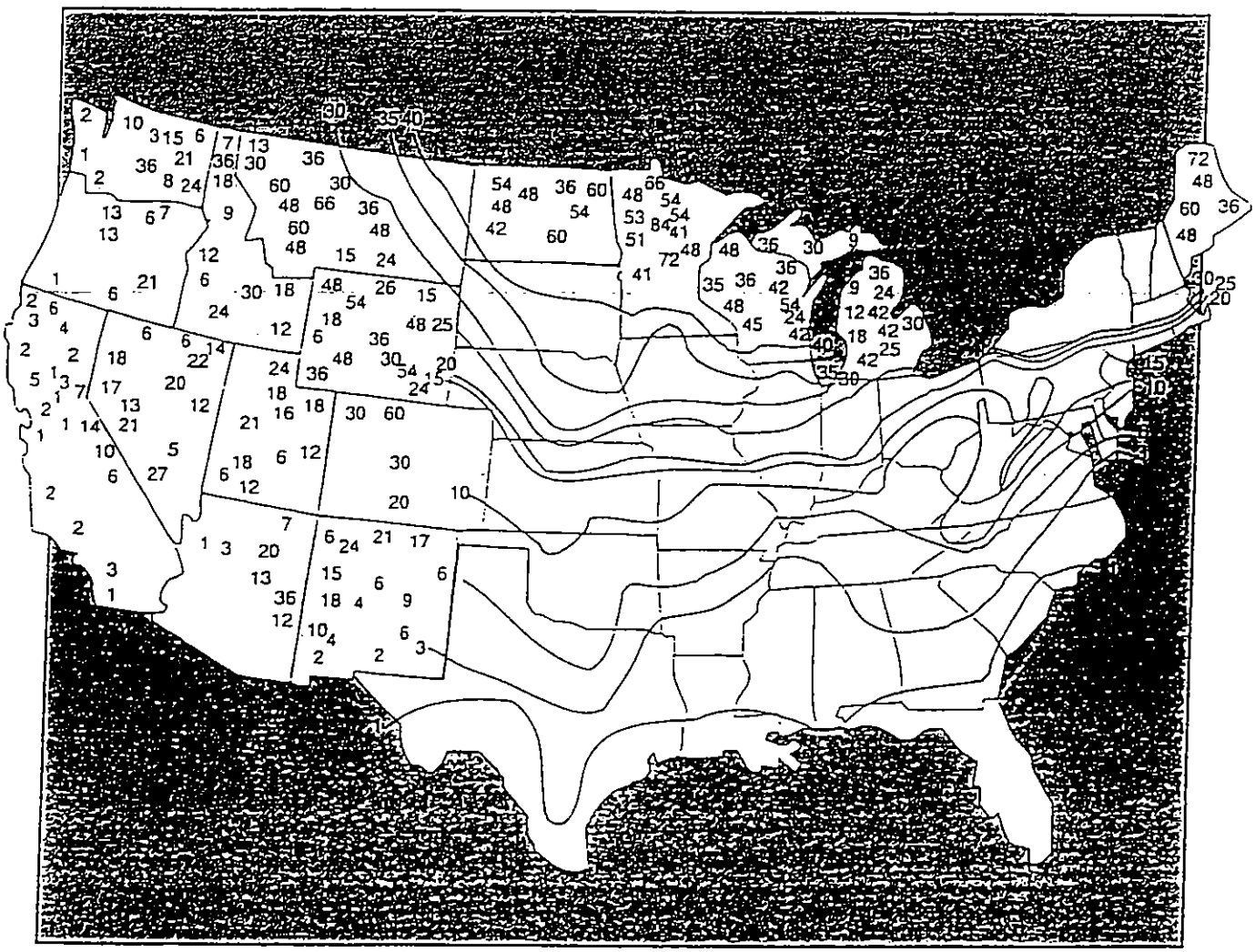
Of the dozens of frost susceptibility criteria currently in use in the United States, a large percentage is based on those described by Casagrande in 1931: "Under natural freezing conditions and with sufficient water supply [from underground] one should expect considerable ice segregation [lensing] in non-uniform soils containing more than 3 percent of grains smaller than 0.02 mm and in very uniform soils containing more than 10 percent smaller than 0.02 mm." Soils with larger percentages of particles smaller than 0.02 mm are classified as frost-susceptible. Another common criterion is to classify any soil with more than 5 percent of particles passing through a No. 200 sieve as frost-susceptible. These soils are most commonly known as fine sand, silty or clayey soils.

Frost Penetration Depth

The depth of frost penetration in soil depends on the rate of heat loss from the ground surface and the ground conditions affecting heat transfer within the soil. The parameters affecting the frost penetration depth are (1) the variation of air temperature, (2) solar insulation, (3) ground surface cover, (4) soil type, (5) soil moisture content, and (6) the location of the groundwater table. The amount of water available from the initial soil moisture content together with any water drawn from the water table influence the depth of frost penetration due to the latent heat of fusion that must be removed for the soil moisture to freeze. The moisture also affects the soil thermal conductivity, specific heat and density, and hence the soil's thermal diffusivity. The Army Corps of Engineers Manual TM 5-852-6 describes this further.

The severity of below-freezing air temperature conditions by location is determined with an air freezing index. One freezing degree day is counted for every degree that the daily average temperature falls below 32°F. For example, three consecutive days with an average daily temperature of 25°F total twenty-one freezing degree days. The annual sum of freezing degree days is termed by the *freezing index*.

There are several procedures that can be used to estimate frost penetration for a particular site using the freezing index. These procedures tend to get quite lengthy, therefore it is recommended that the frost depth for foundation construction be obtained from the local building department or use the average Depth of Frost penetration map (Figure 1) in the absence of other information.



Average Depth of Frost Penetration
in Inches

Source: U.S. Department of Commerce
Weather Bureau

FIGURE NO. 1

Foundation Design Principles

Soil is fully frozen when all the water in it is frozen. This is assumed to have occurred when the temperature of the soil reaches 32°F or below. The foundations are considered safe against frost heave when they are designed so that no fully frozen soil occurs below the bottom of the foundation footer during the winter.

This design condition may be achieved for manufactured homes in one of four ways:

1) Arranging for the foundation depth to be greater than the depth at which fully frozen soil occurs;

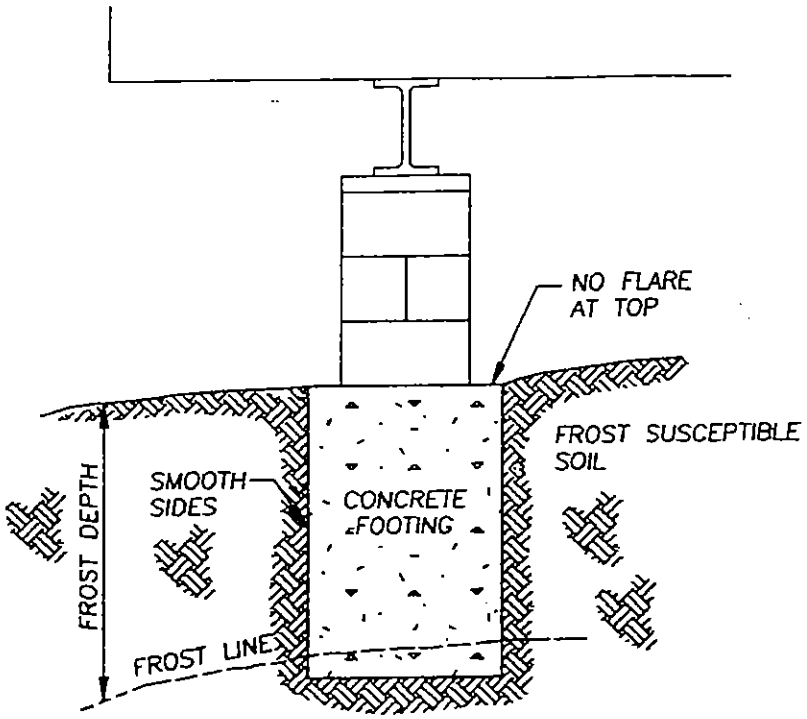
2) Removing frost-susceptible soil from below where the foundations will be built, to the same depth as mentioned in 1, and replacing this with well-drained, non-frost-susceptible material;

3) Insulate the perimeter skirting to reduce heat loss to the exterior, allowing the heat loss through the floor of the home and from the soil below the home, to keep the soil below the foundations unfrozen.

4) Insulate the soil around and below footings to reduce heat loss from the soil under the footings, thus keeping the soil unfrozen.

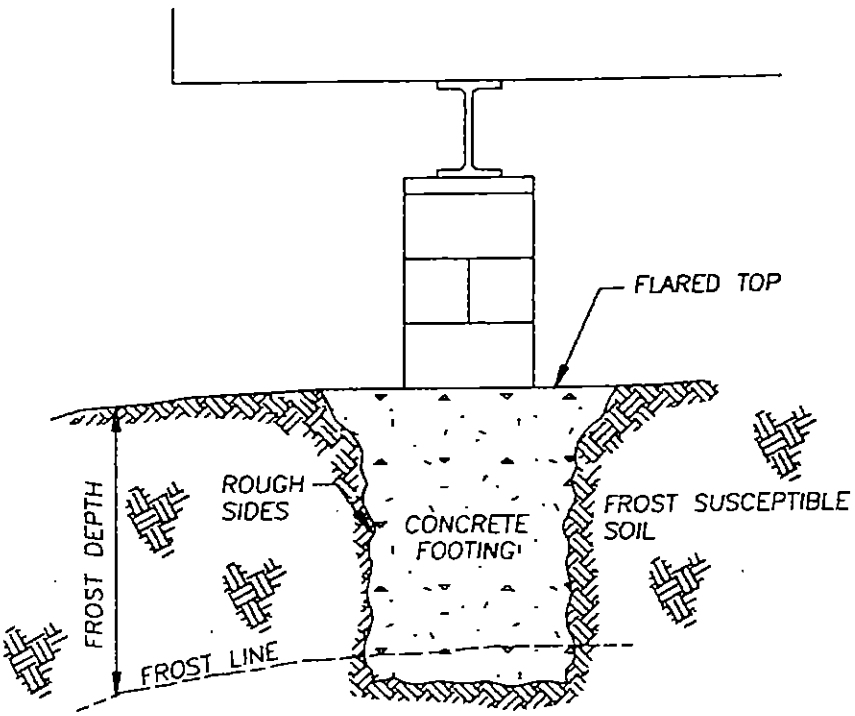
Method No. 1 Footing Below Frost Line

Footings extending to a depth greater than the average frost depth are an acceptable means of support in all locations as long as they are installed properly. See Figures 2 and 3 for illustrated foundation designs.



ACCEPTABLE FOOTING PLACEMENT

FIGURE NO. 2



NOT ACCEPTABLE

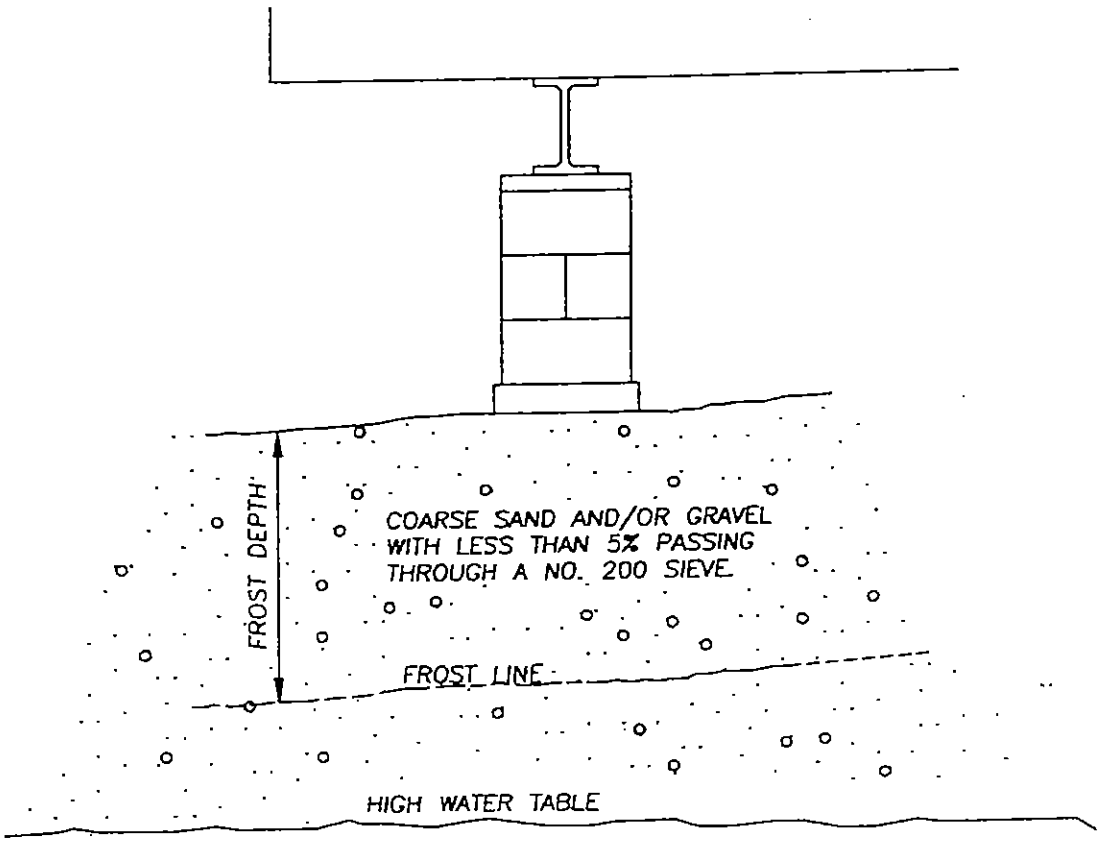
FIGURE NO. 3

Method No. 2 Non-Frost Susceptible Soil

Under rigid building code design criteria, the proposed building site would have soil borings done by a qualified soil scientist to determine the frost susceptibility of the soil and the high water table. If the site has a variation in soil types or water table, the entire site that footings are to be placed would be mapped with soil borings.

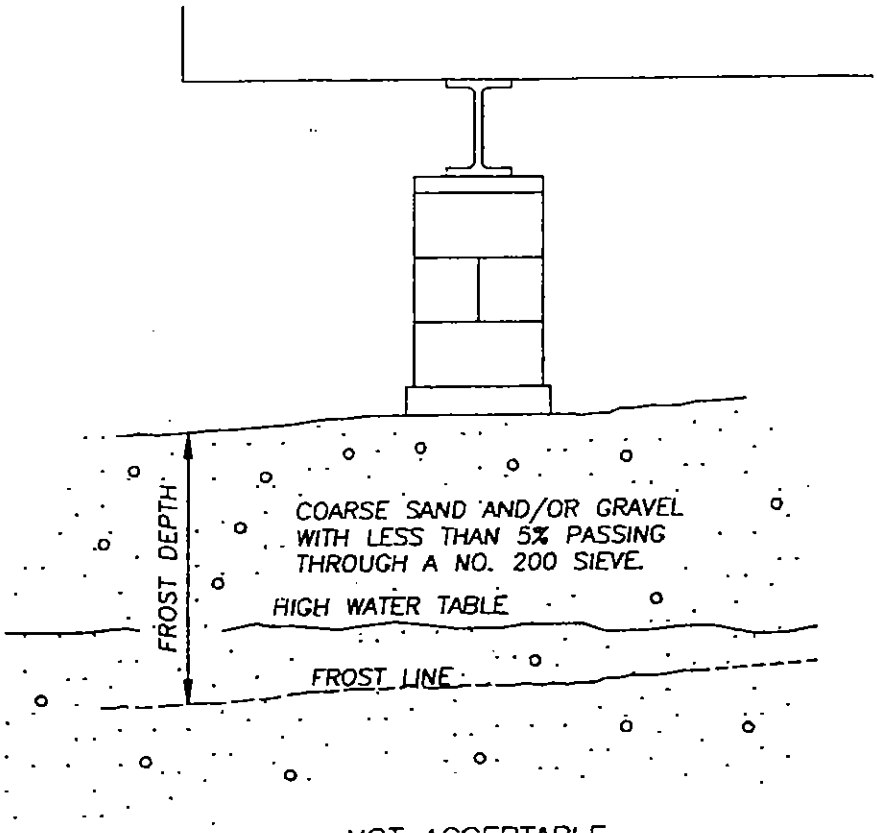
Local health or conservation departments may have soil classification maps available for a specific location. Some locations also have an extension service or Corps of Engineers that have soil classifications and ground water depths available. State manufactured home associations may want to help develop soil classification maps if none are available.

If the soil is not frost susceptible and the water table is below the frost line, the footing may be placed directly upon compacted soil with all vegetation removed. Soil surfaces under the home and along the perimeter should be sloped so that all surface water runs away from the home. See Figure 4 for an acceptable foundation design. Figures 5 and 6 illustrate non-acceptable situations.



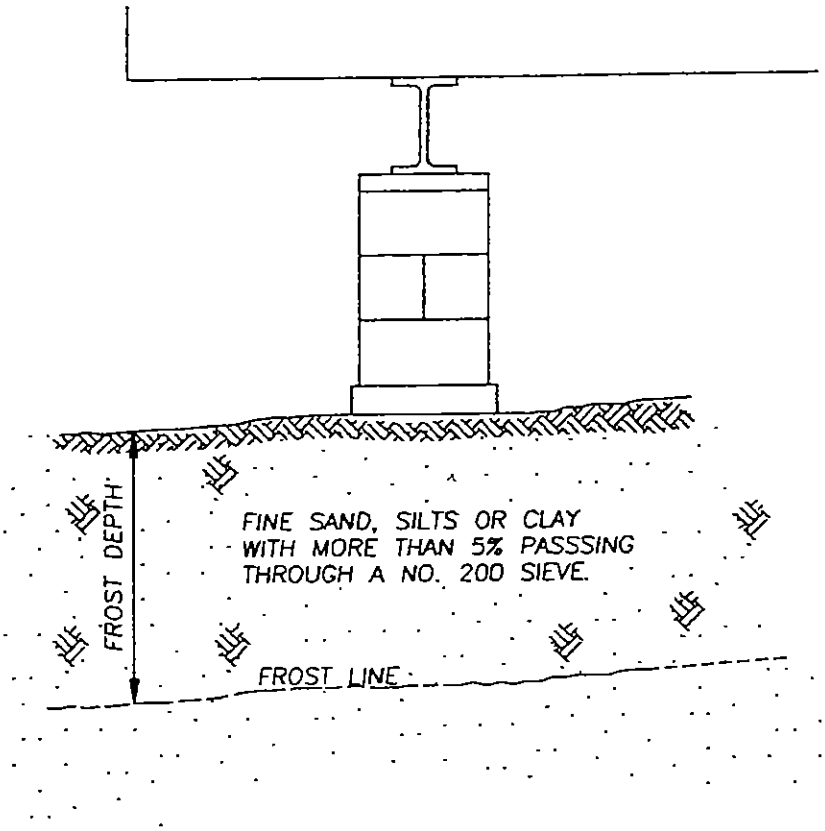
ACCEPTABLE FOOTING PLACEMENT

FIGURE NO. 4



NOT ACCEPTABLE

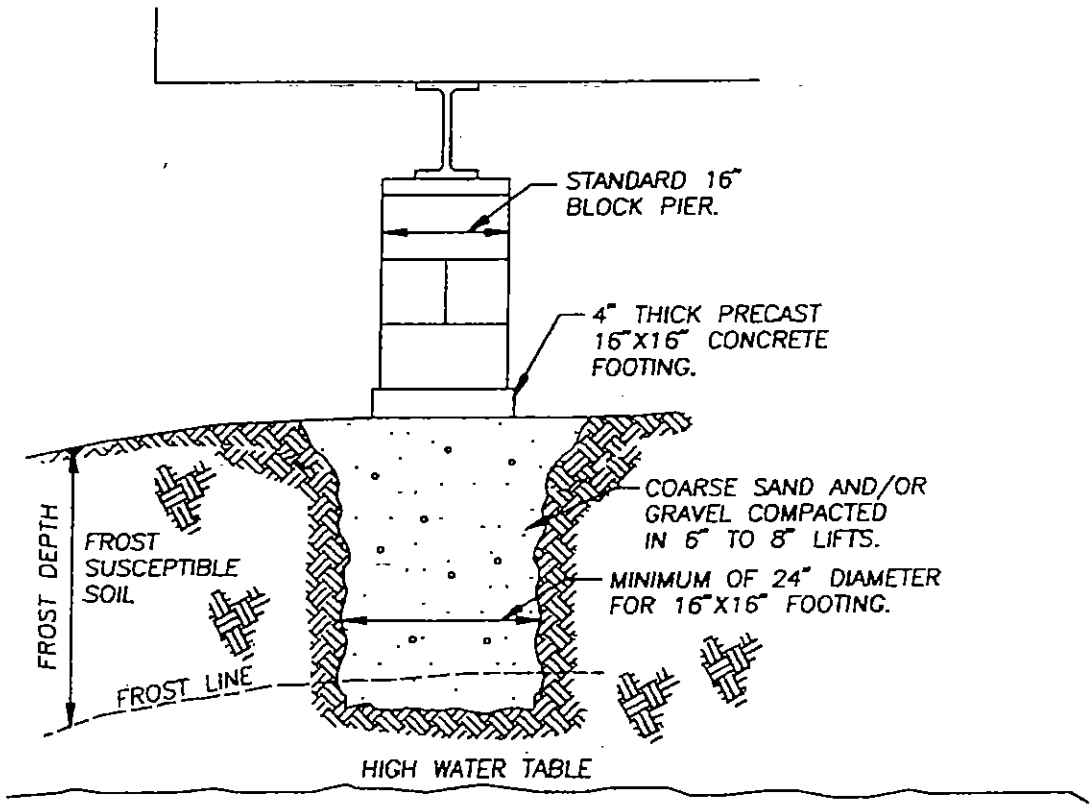
FIGURE NO. 5



NOT ACCEPTABLE

FIGURE NO. 6

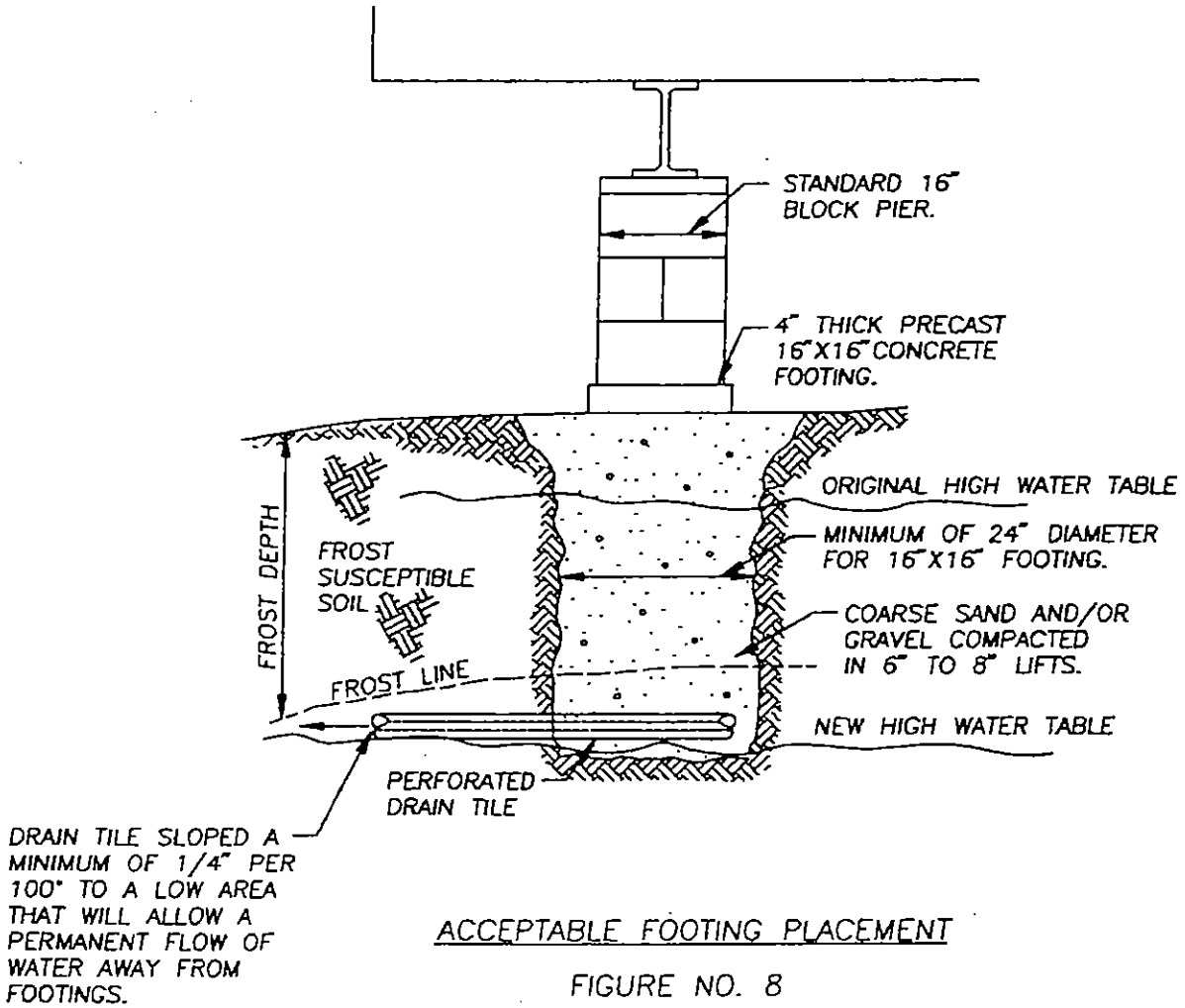
If the soil on a site is frost susceptible and the high water table is below the frost line, the soil below the footing may be removed to a depth below the frost line and replaced with coarse sand and gravel. The sand and gravel should be compacted in 6" to 8" lifts to reduce the possibility of settlement. See Figure 7 for illustrated foundation designs.



ACCEPTABLE FOOTING PLACEMENT

FIGURE NO. 7

If the soil on a site is frost susceptible and the high water table is above the frost line, the soil below the footing may be removed to a depth below the frost line and replaced with coarse sand and gravel. A drainage tile will need to be installed below the frost line to lower the high water table to a point below the frost line. See Figure 8 for illustrated foundation designs.



ACCEPTABLE FOOTING PLACEMENT

FIGURE NO. 8

Method No. 3 Insulated Perimeter Skirting

Perimeter skirting insulation reduces the ground frost penetration under the home as verified in the tests done in Green Bay, Wisconsin during 1994-1995 and Midland, Michigan during 1995-1996. It is also evident that open vents in the skirting reduces the temperature under the home, thus increasing the frost penetration. Ventilation through the skirting is necessary during warm humid weather, therefore it will be necessary to make sure these vents are closed during freezing weather to make this a viable alternative for frost protection. The thickness, type and location of insulation should be per Figures 9 and 10 and Tables 1 and 2.

Frost Depth "A"	Insulation thickness "B"	Set Back Dimension "C"
6"	NR	12"
12"	.75"	12"
18"	1.0"	12"
24"	1.5"	16"
36"	2.0"	20"
48"	2.0"	24"
60"	3.0"	30"

Table No. 1

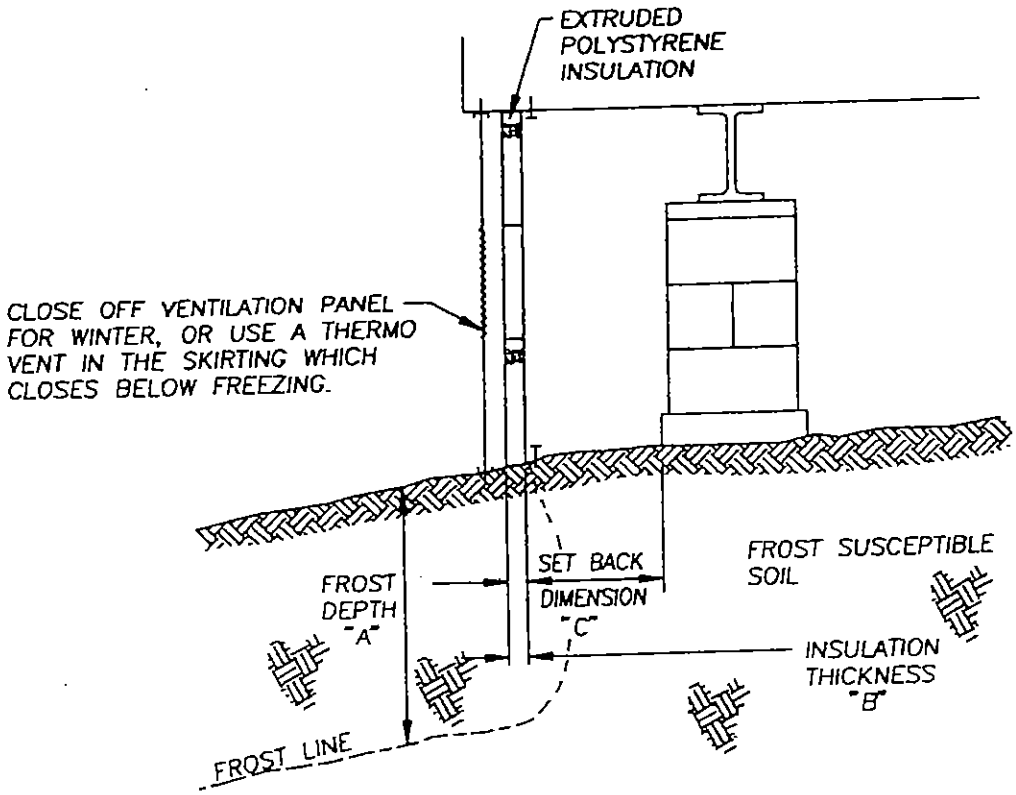


FIGURE NO. 9

Frost Depth "A"	Horizontal Insulation Thickness "B"	Horizontal Insulation Width "C"	Horizontal Insulation Extension "D"
6"	NR	NR	NR
12"	.75"	12"	12"
18"	1.0"	18"	18"
24"	1.5"	24"	24"
36"	2.0"	30"	30"
48"	2.0"	30"	30"
60"	3.0"	36"	36"

Table No. 2

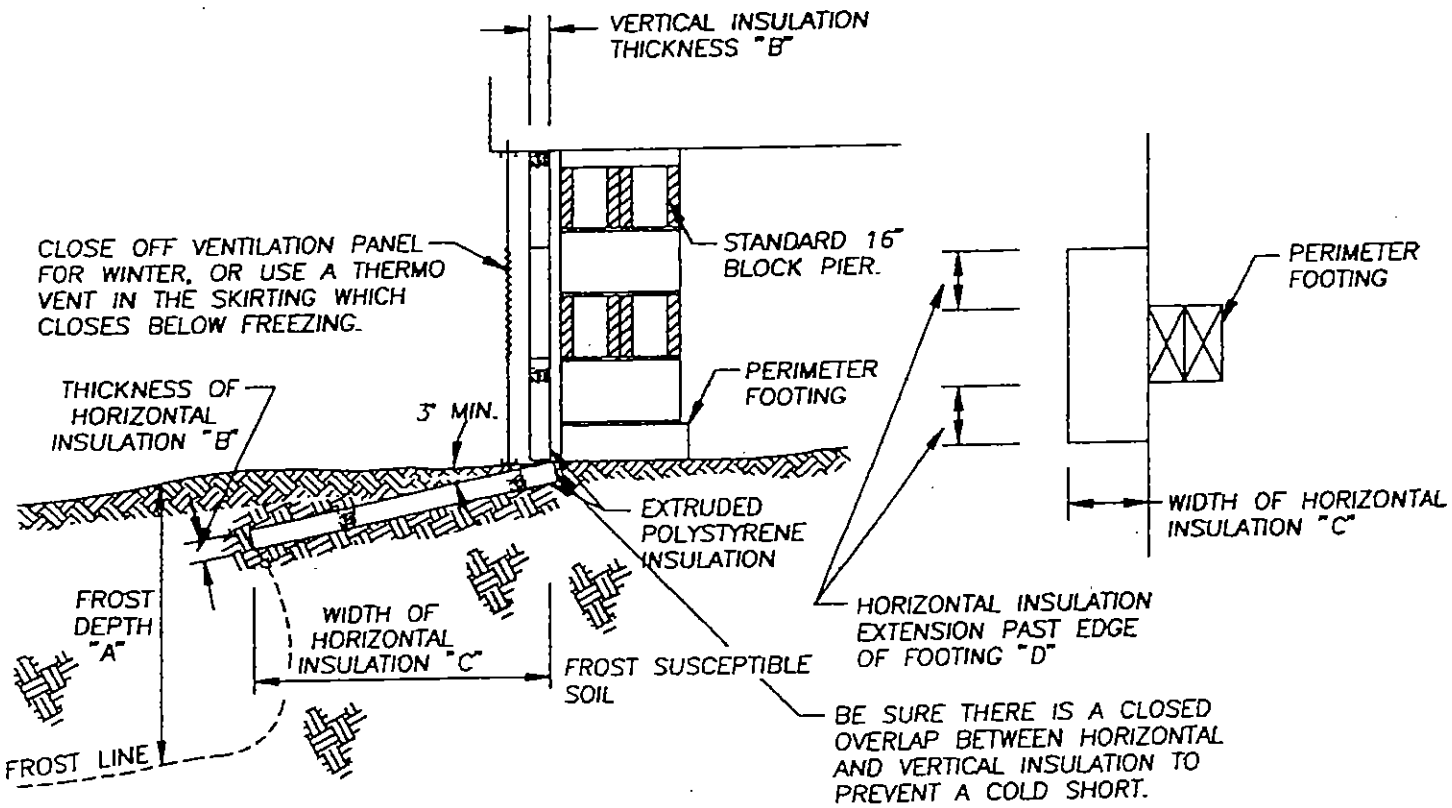


FIGURE NO. 10

Method No. 4 Insulation Below Footing

This method assumes that the space enclosed by the skirting under the home is within about 8°F of the outside air temperature, such as when skirting vents are not closed during freezing periods. Extruded polystyrene insulation is placed horizontally below each footing per Figures 11 and 12, and Table 3 to prevent frost penetration under the footing.

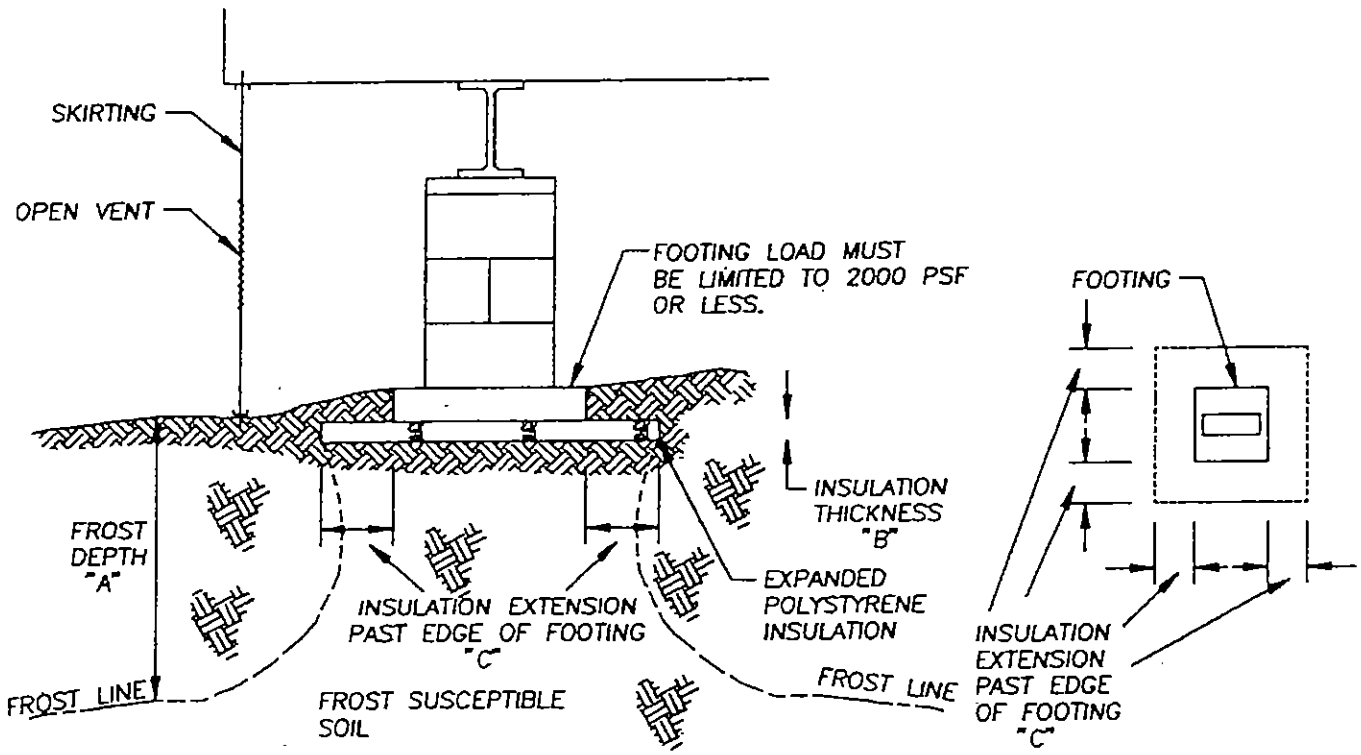


FIGURE NO. 11

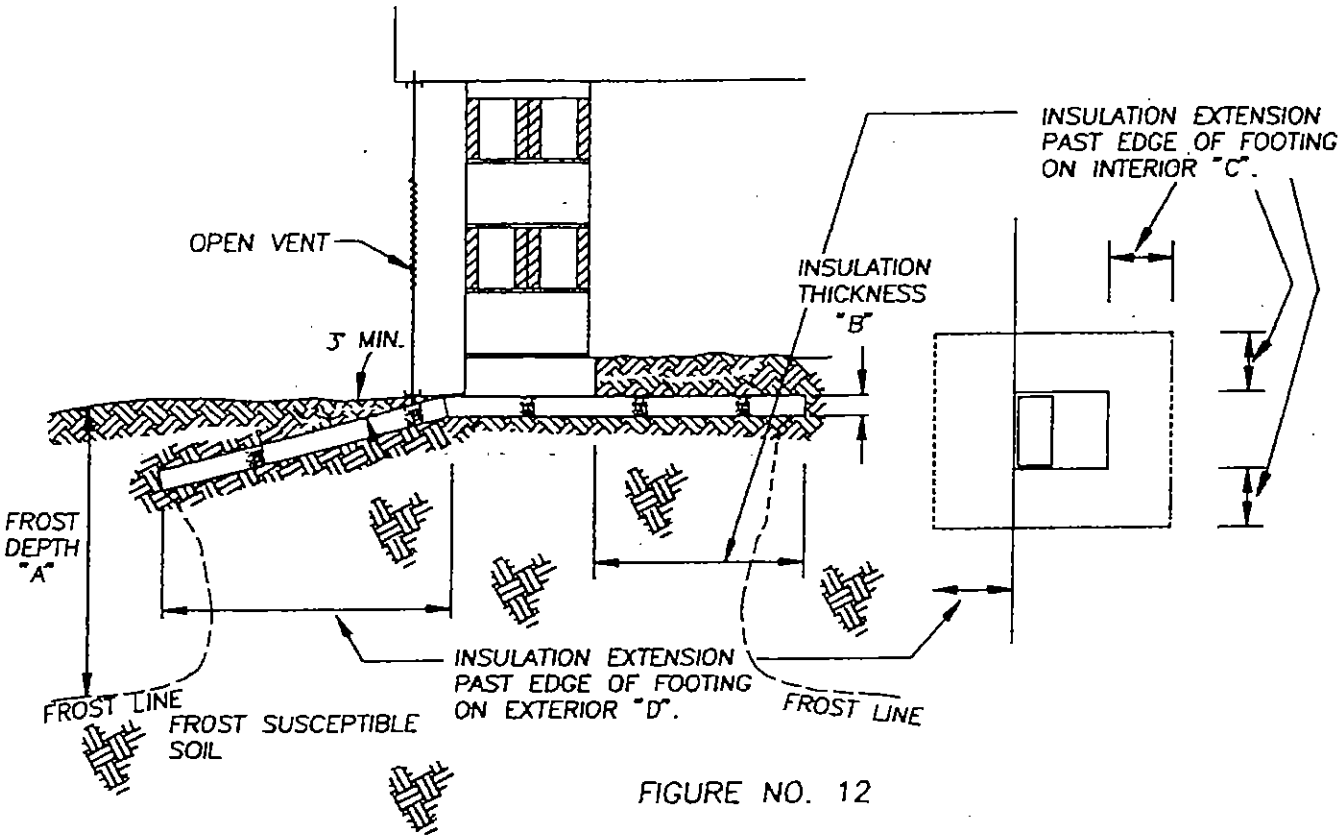


FIGURE NO. 12

Frost Depth "A"	Insulation Thickness "B"	Interior Horizontal Extension "C"	Exterior Horizontal Extension "D"
6"	NR	NR	NR
12"	1.0"	24"	30"
18"	1.5"	36"	42"
24"	2.0"	48"	54"
36"	3.0"	72"	78"
48"	4.0"	84"	90"
60"	5.0"	96"	96"

Table No. 3

Discussion of 1994-1995 Test Results

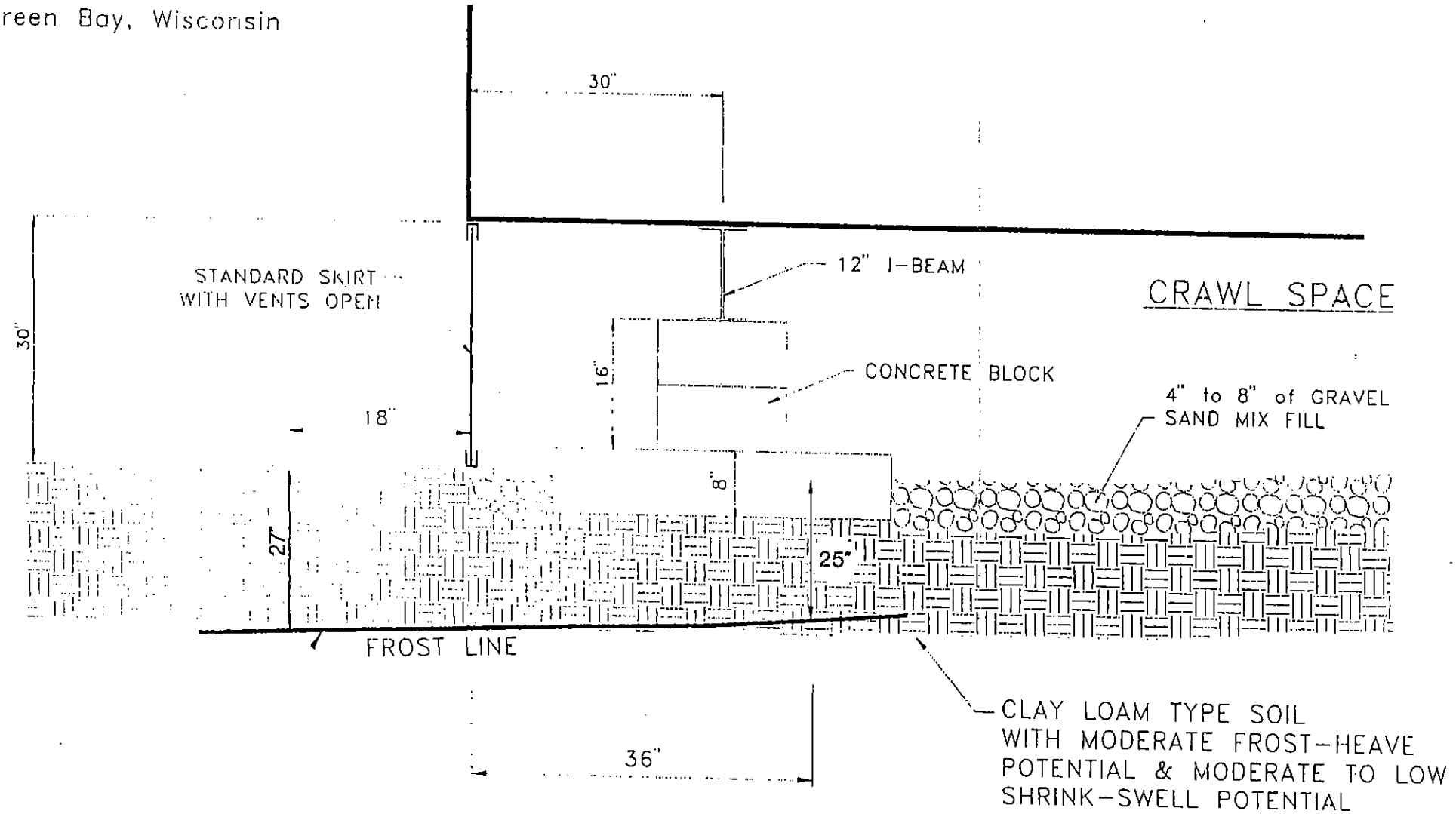
One home at 1331 Bellvue St. in Green Bay, Wisconsin with standard skirting and vents left open was instrumented for frost penetration. The soil under this home was a clay loam type with a moderate frost heave potential. This home was also subject to wind from most directions. See Figure 13 for the maximum frost depth penetration during the winter of 1994-1995.

A second home at 209 Camilla Lane, Green Bay, Wisconsin with standard skirting (vent panels closed) with 1 inch of expanded polystyrene insulation behind the skirting was also instrumented for frost penetration. This home also had a clay loam type soil under the home with a moderate frost heave potential. This home was protected some what by other homes from the wind. See Figure 14 for the maximum frost depth penetration during the winter of 1994-1995.

Figures 13 and 14 illustrate very well the effect insulation and closed vents have on frost depth penetration. Figure 15 illustrates the difference on the temperature below the two homes. These tests show us that the under floor space follows the outside temperature very closely when standard skirting is used and the vents are left open.

Neither home was tied down and visual inspections showed no signs of frost heave at either home. The lack of frost heave may be due to the very mild winter or may be due to the fact that heavy clay tends not to migrate water well, thus slowing the formation of ice lenses.

1331 Bellvue St.
Green Bay, Wisconsin



MAXIMUM FROST DEPTH
IN FEBRUARY FOR WINTER
OF 1994-1995

Figure 13

15

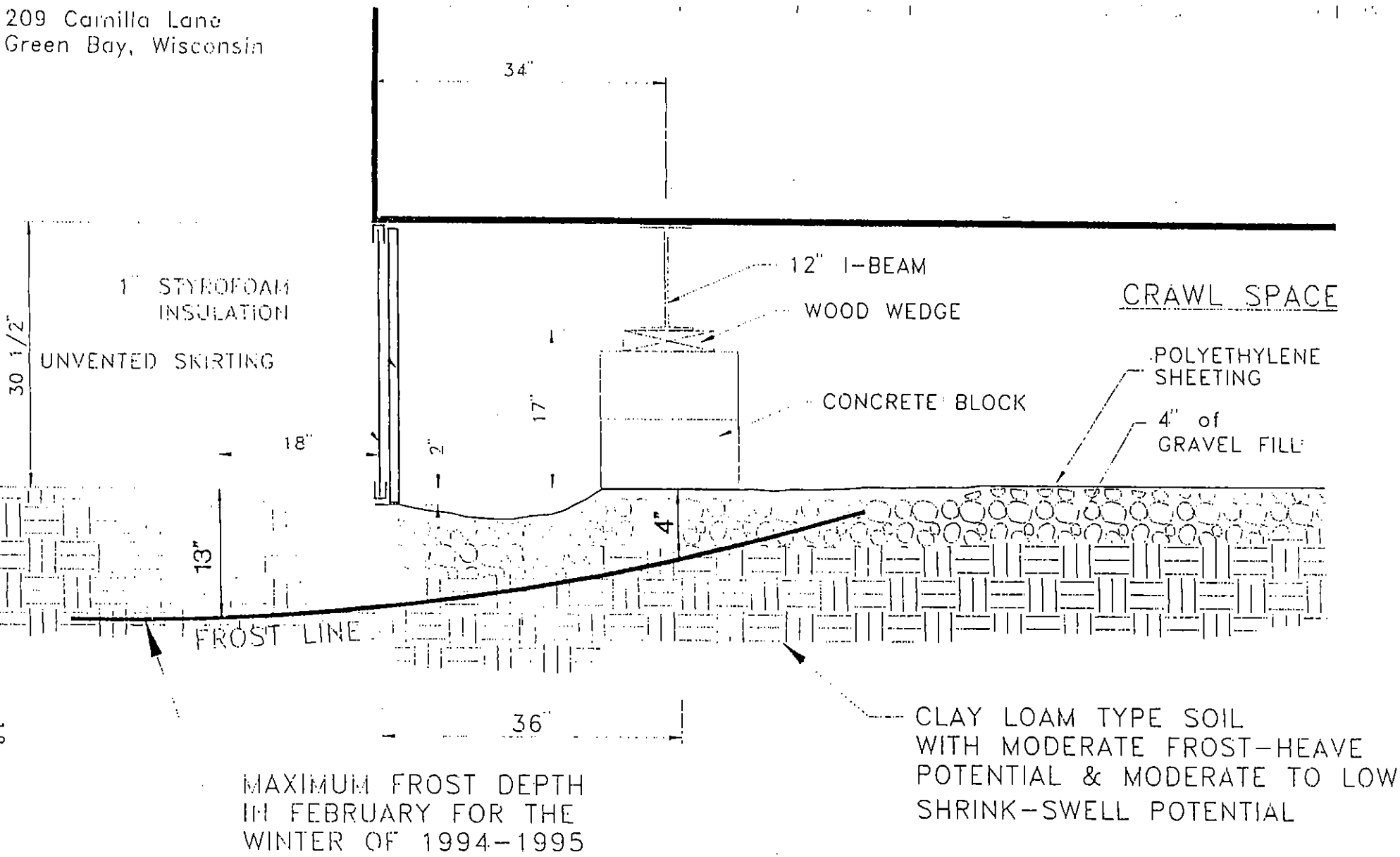

209 Carnilla Lane
Green Bay, Wisconsin
34"
1" STYROFOAM INSULATION
UNVENTED SKIRTING
30 1/2"
18"
13"
2"
17"
4"
12" I-BEAM
WOOD WEDGE
CONCRETE BLOCK
CRAWL SPACE
POLYETHYLENE SHEETING
4" of GRAVEL FILL
FROST LINE
36"
MAXIMUM FROST DEPTH IN FEBRUARY FOR THE WINTER OF 1994-1995
CLAY LOAM TYPE SOIL WITH MODERATE FROST-HEAVE POTENTIAL & MODERATE TO LOW SHRINK-SWELL POTENTIAL

Figure 14

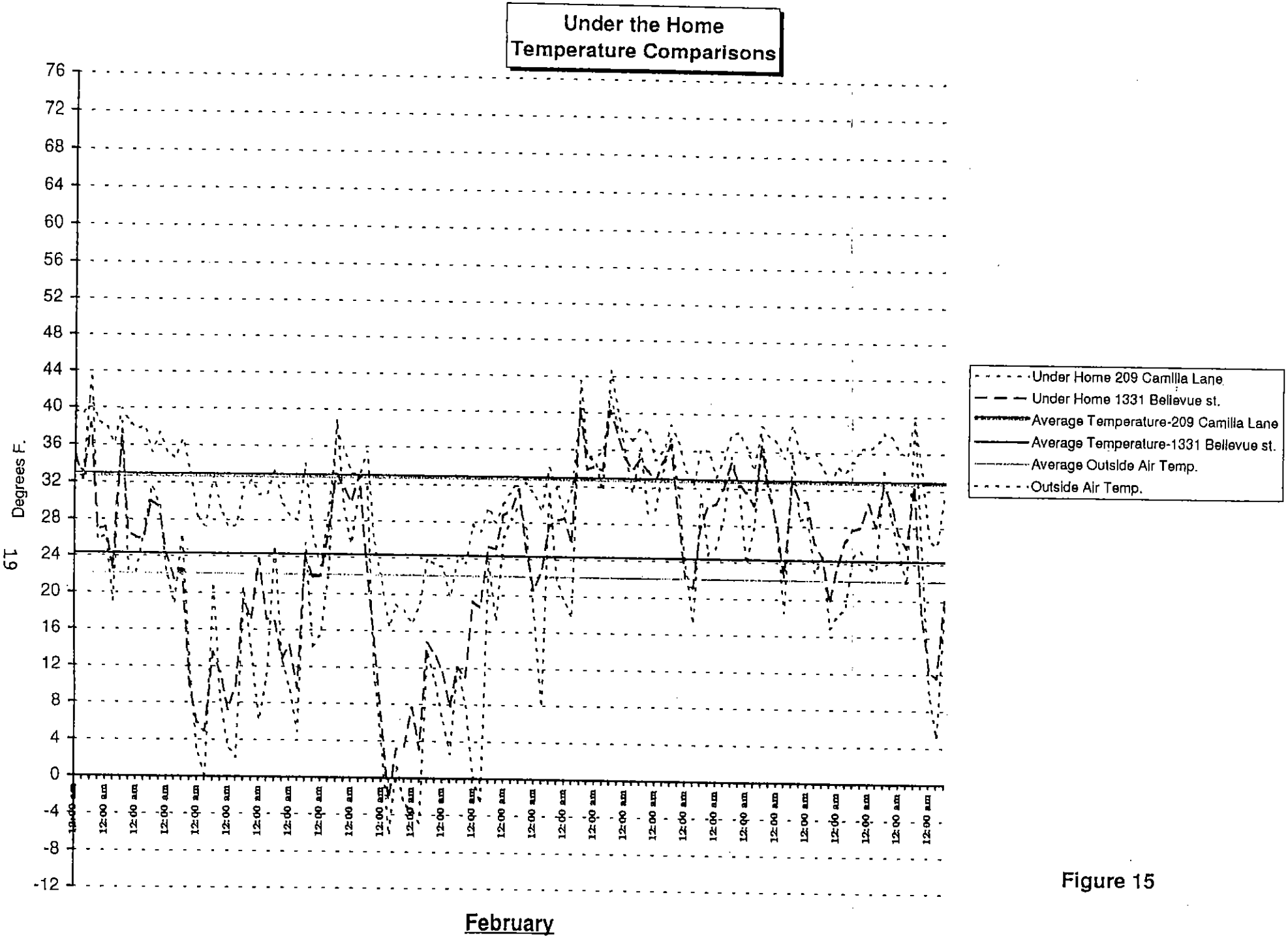


Figure 15

Chart No. 78

15

Discussion of 1995-1996 Test Results

One home at 3304 Holly Court, Midland, Michigan was set-up with 1½" insulation behind skirting with four (4) temperature controlled vents. 1½" thick x 30" wide insulation was placed horizontally under the ground surface at all perimeter piers. The home was tied down to and blocked from concrete runners. A 6 mil polyethylene vapor barrier was placed on the floor of the crawl space and the dryer vent was ducted to the exterior. This home was instrumented with temperature probes (at one interior pier location and one perimeter pier location) to measure frost penetration; temperature probes to measure air temperatures inside, outside and under the home; a humidity probe under the home and two (2) displacement transducers (one at an interior pier and one at a perimeter pier). The soil under this home was heavy clay containing pockets of sandy loam with a fairly high frost heave potential. This home was protected from the wind by trees and other units to the south, west and north. See Figures 16 and 17 for the maximum frost depth penetration during the winter of 1995-1996.

A second home at 3408 West Columbine, Midland, Michigan was set-up with 2" insulation behind skirting with a humidistaticaly controlled power vent. 2" thick x 30" wide insulation was placed horizontally under the ground surface at all perimeter piers. The home was tied down to and blocked from concrete runners. A 6 mil polyethylene vapor barrier was placed on the floor of the crawl space and the dryer vent ducted to the exterior. This home was instrumented with temperature probes (at one interior pier location and one perimeter pier location) to measure frost penetration; temperature probes to measure air temperatures inside, outside and under the home; a humidity probe under the home and two (2) displacement transducers (one at an interior pier and one at a perimeter pier). The soil under this home was also heavy clay containing pockets of sandy loam with a fairly high frost heave potential. This home was protected on all sides from the wind by trees and other units. See Figures 18 and 19 for the maximum frost depth penetration during the winter of 1995-1996.

A third home at 3412 West Columbine, Midland, Michigan was a typical home with uninsulated skirting and no vents. The home was tied down to and blocked from concrete runners. The home had no vapor barrier on the ground and the dryer vent was ducted into the crawl space area. This home was instrumented with two (2) displacement transducers (one at an interior pier and one at a perimeter pier). The soil under this home was also heavy clay containing pockets of sandy loam with a fairly high frost heave potential. This home was also protected on all sides from the wind by trees and other units.

Figures 16, 17, 18 and 19 illustrate quite well how insulated skirting can keep the soil under a home from freezing. Figure 20 for units monitored during 1995-1996 vs. Figure 15 for units monitored during 1994-1995 illustrates very well the ability of insulated skirting to keep the under floor space temperature above freezing. The home with 2" of insulation had a slightly lower average crawl space temperature than the home with 1½" insulation. This could have been due to the use of a power vent system vs. the thermo vents. Further study and testing on the effects of these vents would need to be done before a recommendation to reduce insulation thickness in Tables 1 and 2 could be made. At the perimeter pier locations the horizontal insulation was placed only on the exterior of the skirting and left a cold short where the skirting made contact with the soil. This allows unwanted frost penetration under the perimeter pier. Therefore it is very important that the horizontal insulation under the ground surface connect up with the vertical insulation behind the skirting. See Figure 10 for an illustration of this recommendation. One location on the home at 3304 Holly Court experienced frost heave at the skirting sufficient to bow the 1½" thick insulation outward, causing the skirting to bow outward. Some type of insulation overlap system may need to be used in areas of large frost heave to prevent unwanted horizontal displacements of the insulation and skirting. Further study of this condition should be done to ensure proper functioning of the insulation.

Figure 21 illustrates that both ventilation systems, four thermo vents and power vent on a humidistat, produced the same humidity in the under floor space. The average humidity under both homes during the months of December, January and February was 48% to 49%. Both homes (3304 Holly Court and 3408 West Columbine) experienced frost along the bottom of windows, window frames and door bottoms during the winter, therefore no conclusions can be made as to the effect on the humidity within the home. Further study may want to be done to determine if either vent system has a negative impact on the functioning of insulation.

Figures 22 and 23 illustrate the comparative displacements of the three (3) homes during the month of February.

The displacement maximum was .084" on the interior footing of the home with 1½" of perimeter insulation and .109" on the exterior footing of the home with 1½" of perimeter insulation. The home with no insulation had a maximum displacement of .031", therefore it can be concluded that either the under floor space was held above freezing temperatures by heat loss through the floor and the dryer vent discharging into the crawl space or that even though there is frost penetration under the footings, no major displacement takes place. Due to the major expansion at the skirting of the home at 3304 Holly Court, we have concluded that the soil under the home at the footings was kept from expanding due to freezing. Further testing under more controlled conditions needs to be done to determine what conditions actually do cause any significant displacement. The maximum displacement of .109" on the insulated home is insufficient and would not be noticed or create any problems. All tie-downs were snug on all three homes at the beginning of the test and experienced no noticeable changes during the test. The utility connections remained in alignment throughout the test as well.

LOCATION B
5304 HOLLY COURT
MIDLAND, MICHIGAN

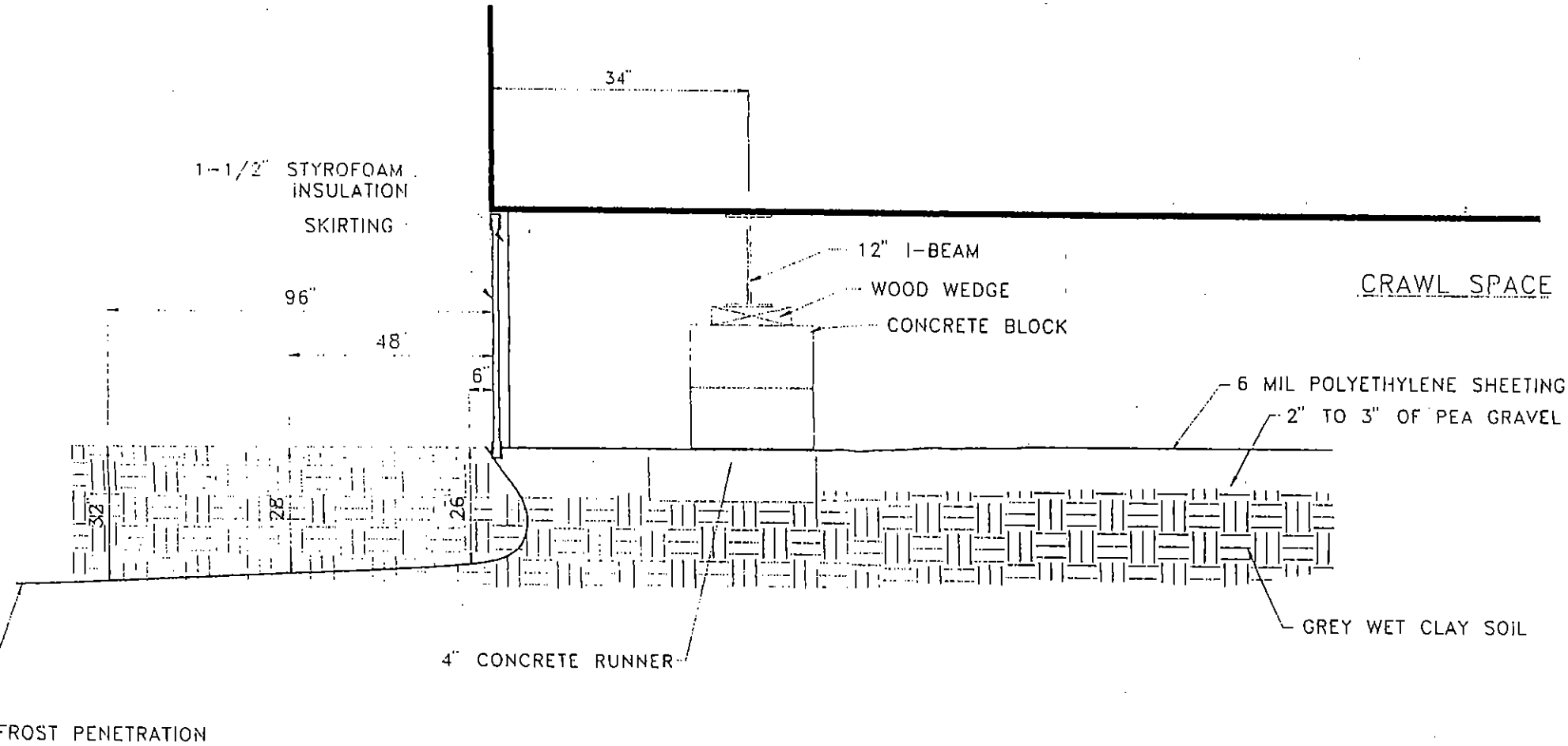


Figure 16

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CATION A
04 HOLLY COURT
OLAND, MICHIGAN

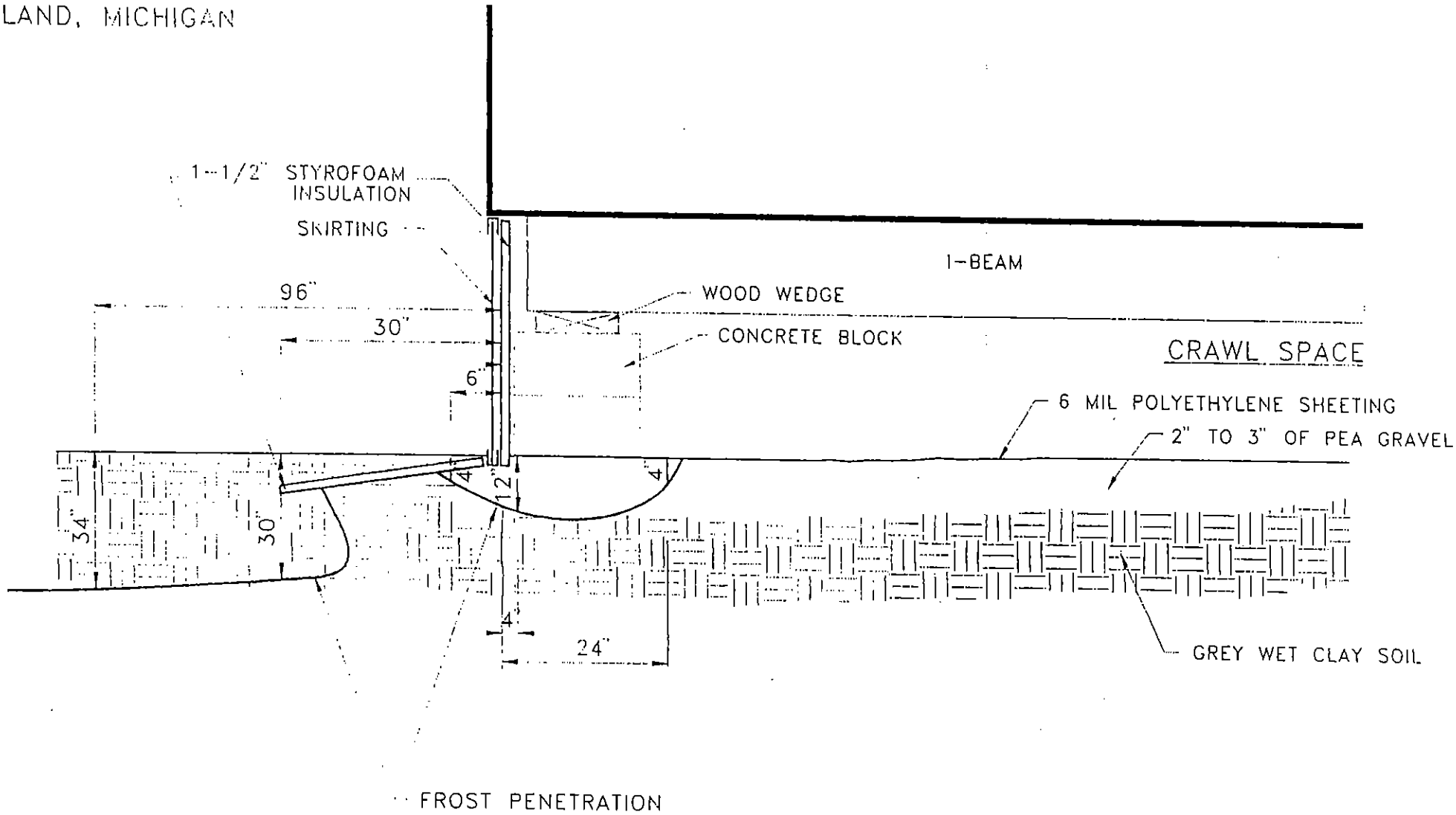

Figure 17

CATION B
08 WEST COLUMBINE
OLAND, MICHIGAN

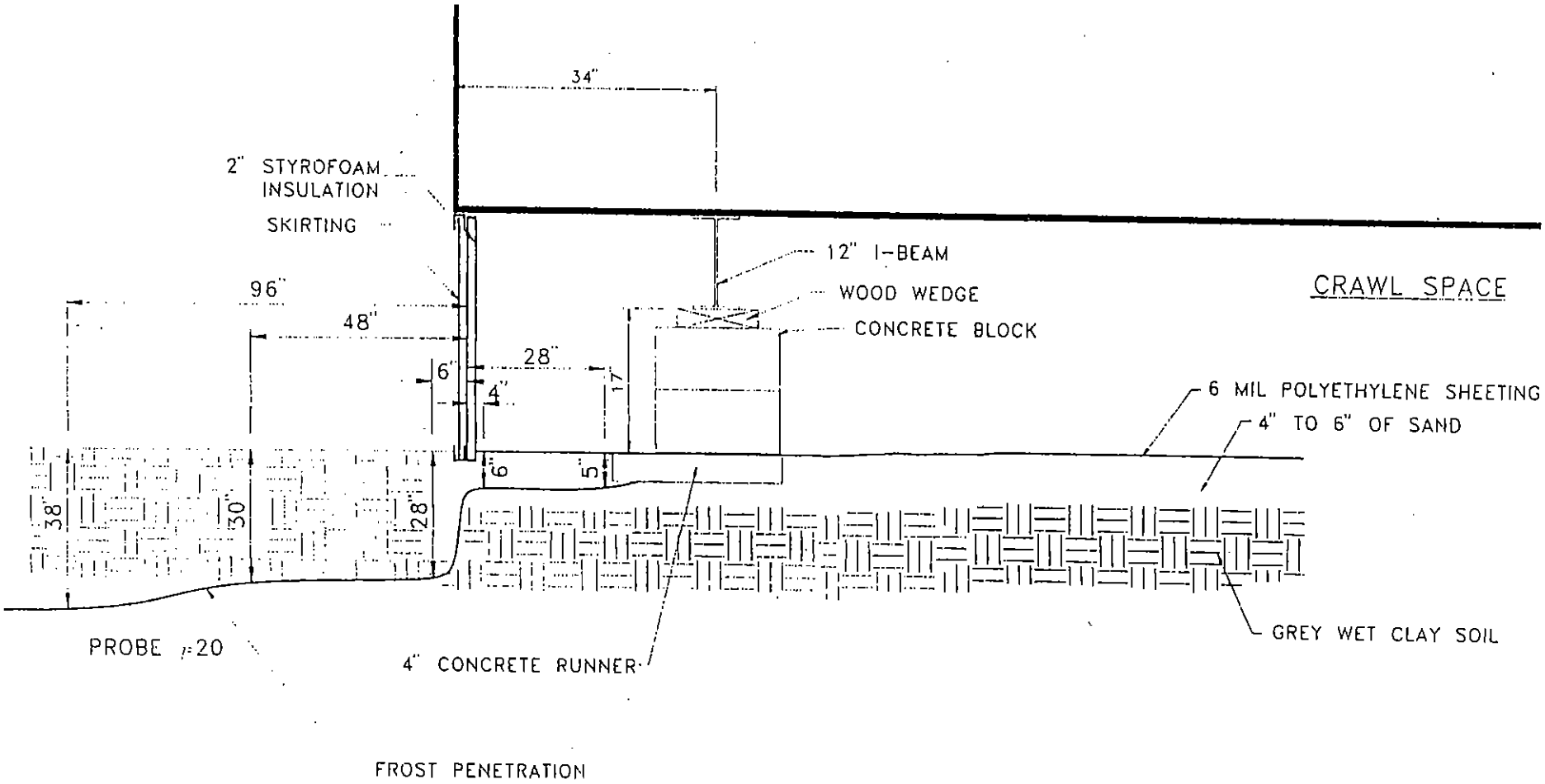

Figure 18

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LOCATION A
3408 WEST COLUMBINE
MIDLAND, MICHIGAN

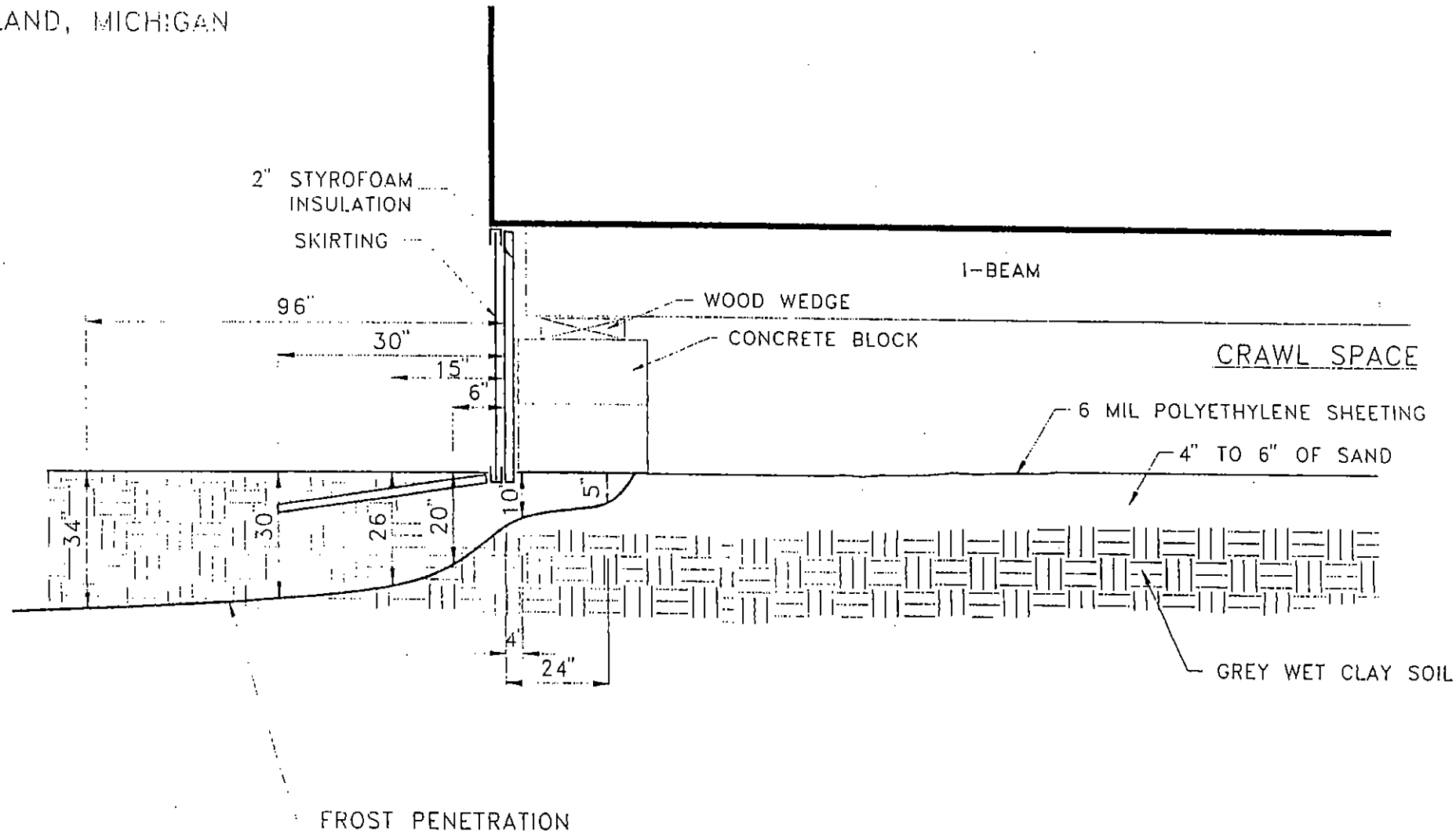

Figure 19

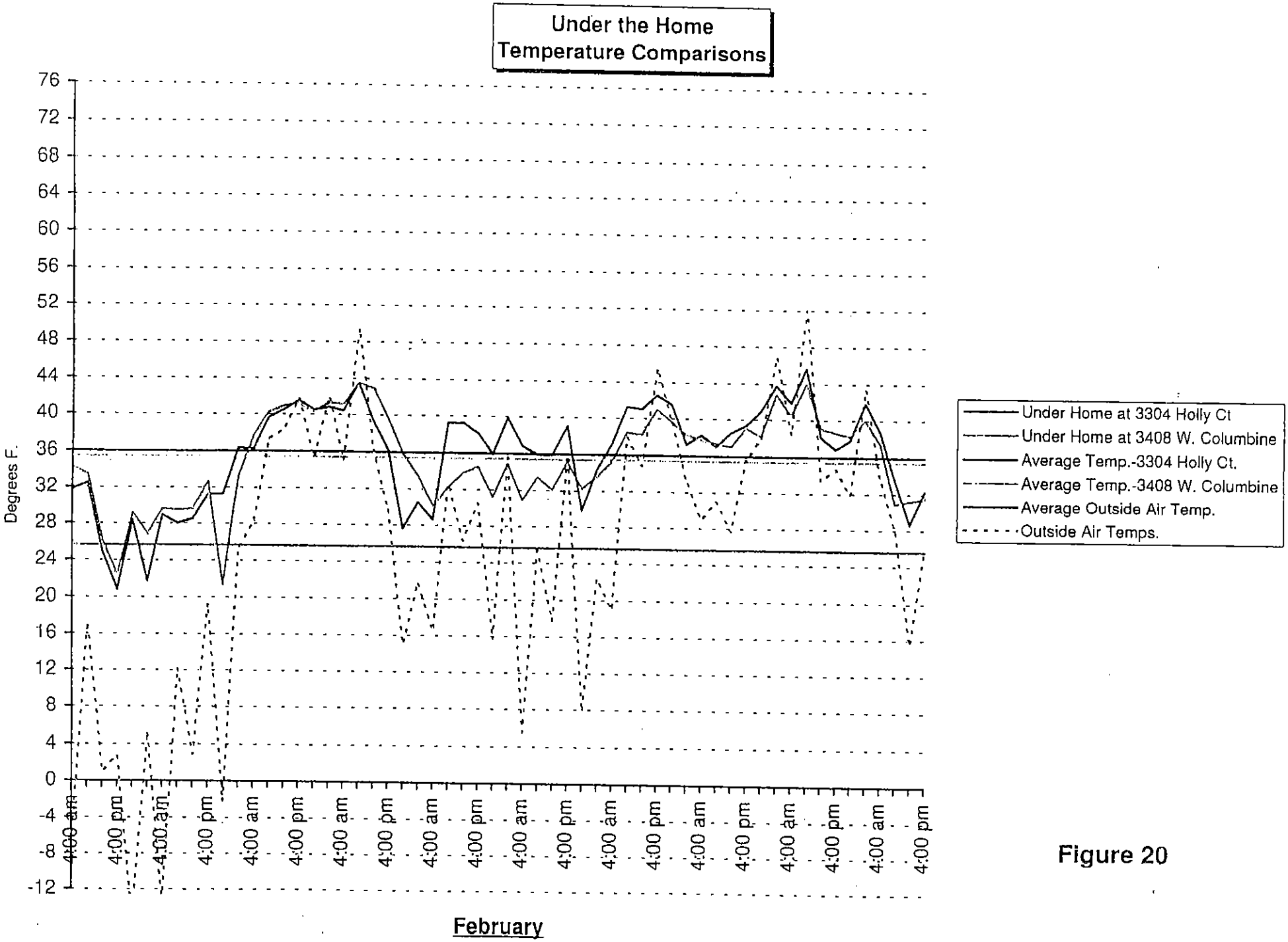

Figure 20

Chart No.80

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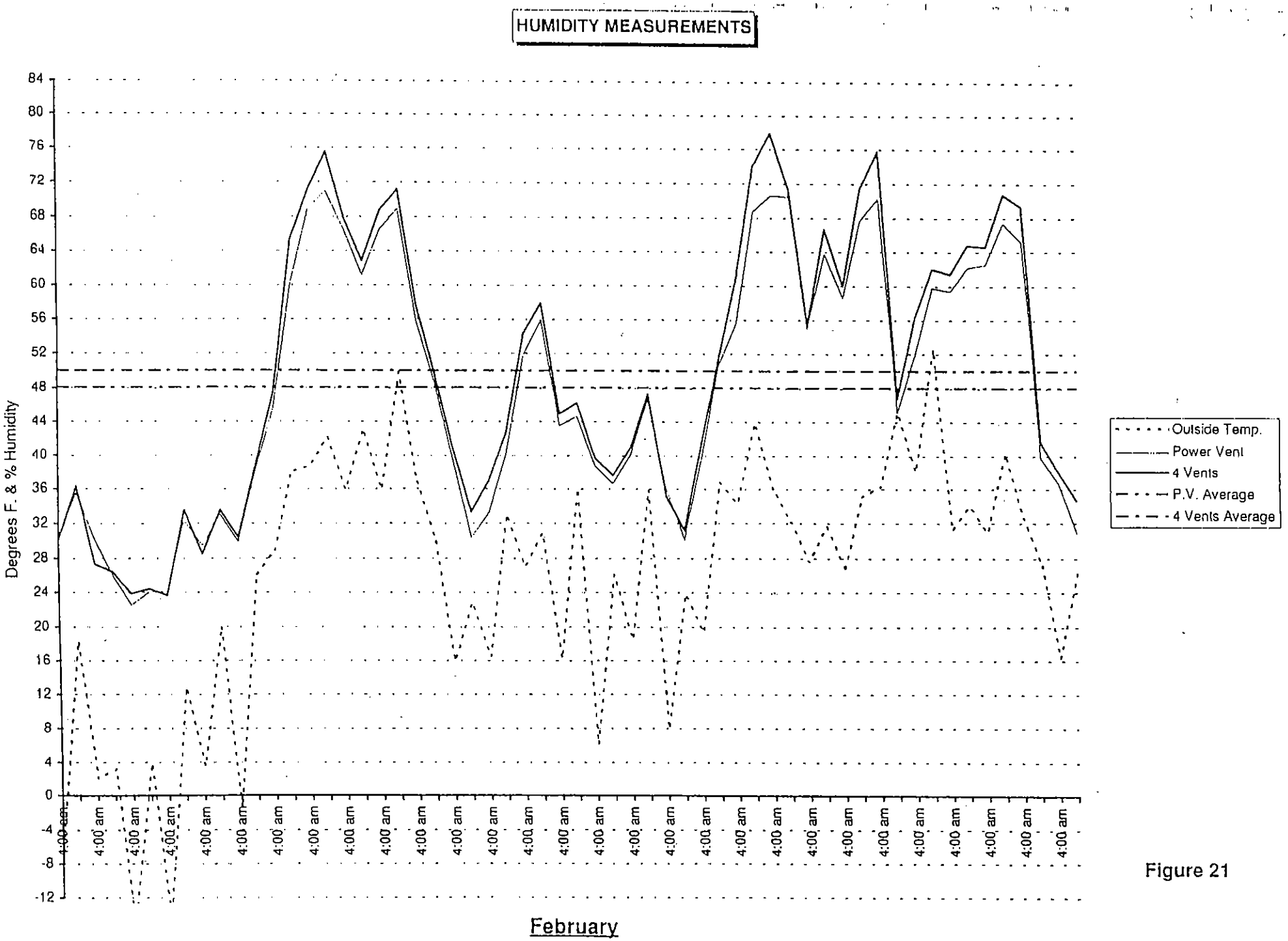

Figure 21

Chart No.72

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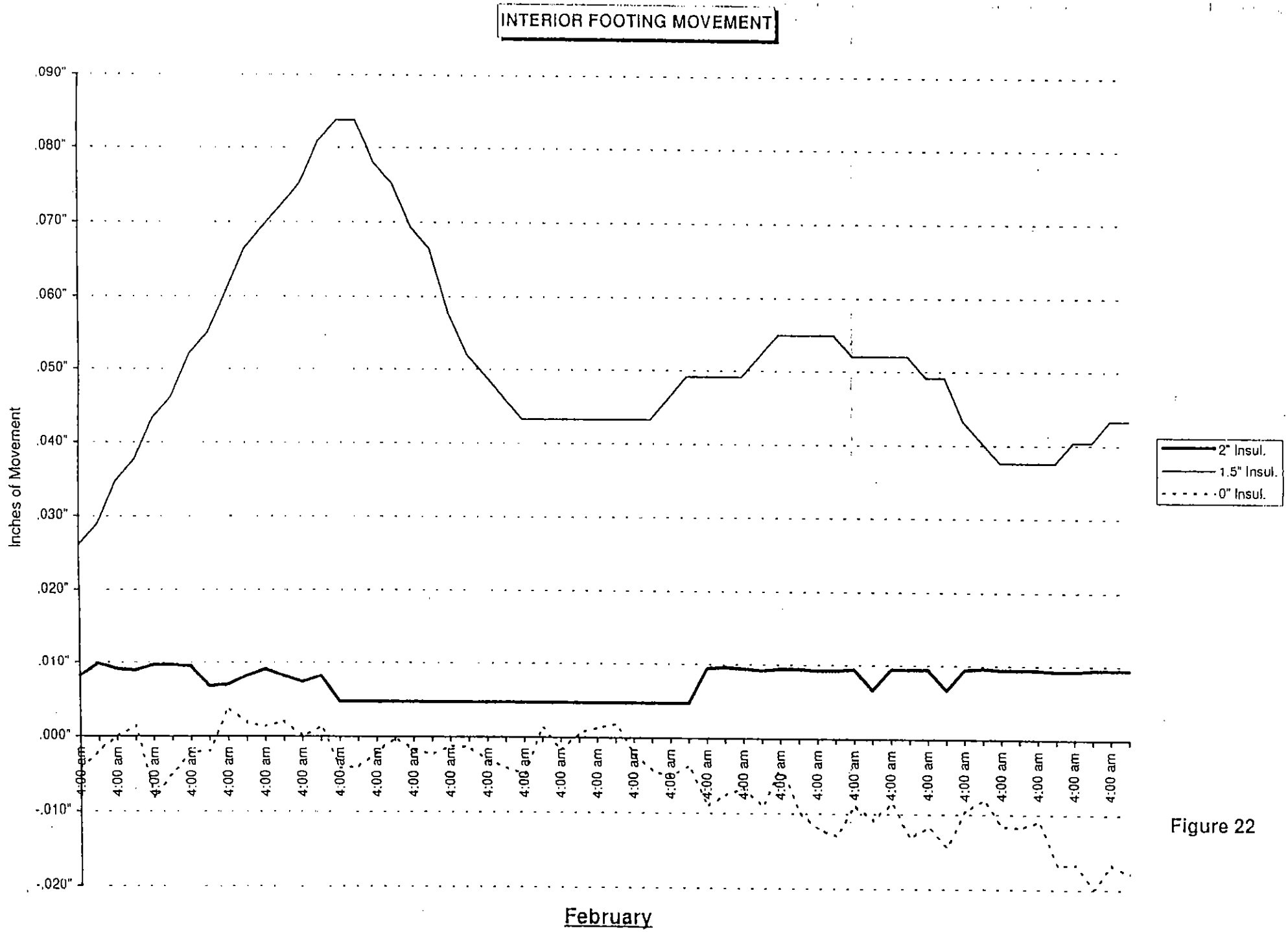

Figure 22

Chart No.75

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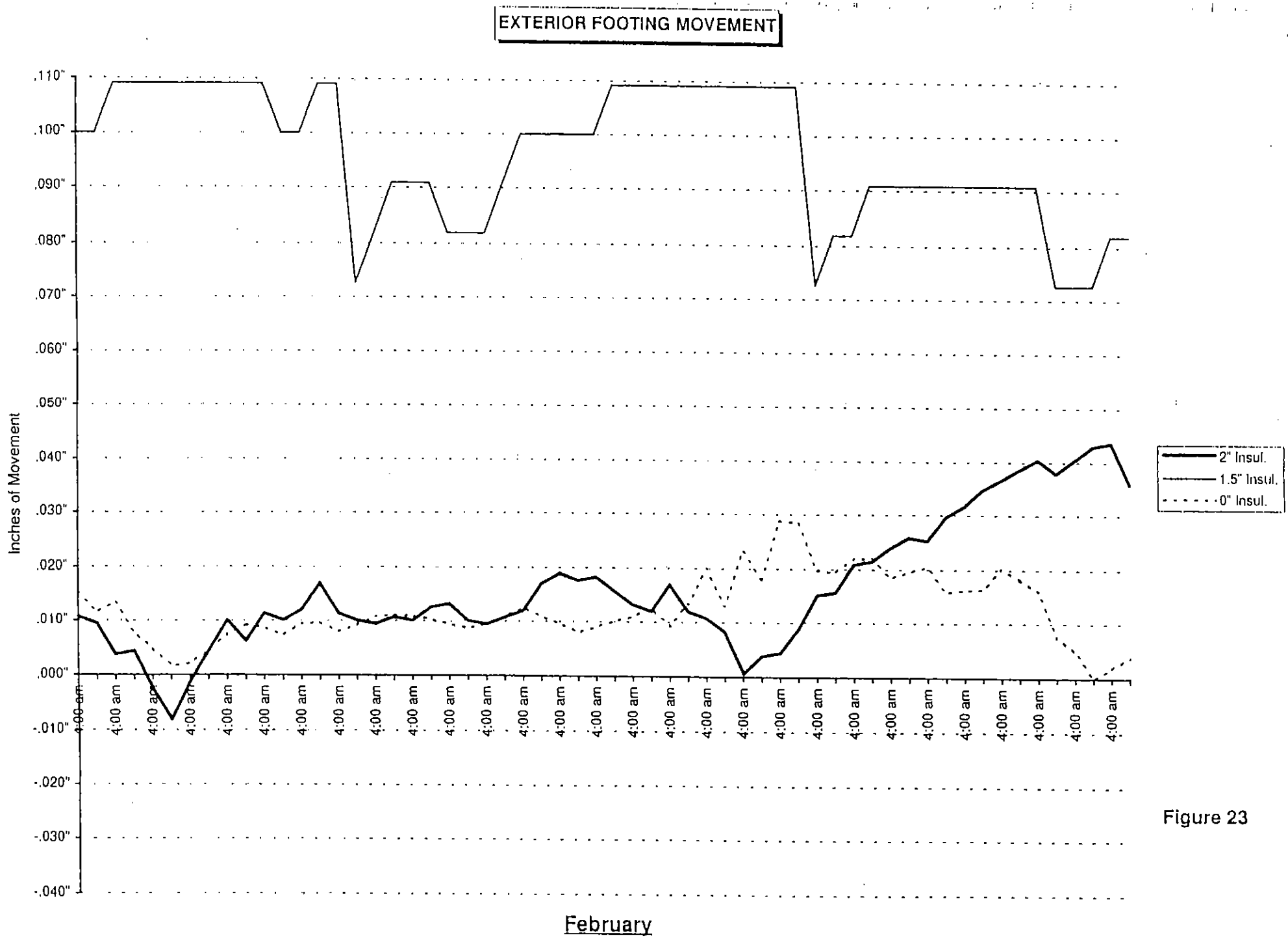

Figure 23

Chart No.78

Cost Comparisons

For cost comparison purposes we selected the 14 x 80 (13½ ft. x 76 ft. box) home at 3408 West Columbine in Midland Michigan to make all comparisons. The home had 18 piers total and was blocked such that there was approximately 30" between the bottom of the floor and ground. Midland, Michigan has a 42" footing depth requirement.

1. **Footing Cost:**

A. Cost for footings below frost consisting of eighteen (18) 16" Dia. x 42" deep concrete:

$55.00(*)/pier x 18 piers = $990.00

B. Cost for footings consisting of two (2) 30" wide x 4" deep x 76' long concrete runners.

Total cost $490.00(*)

C. Cost for installing footings consisting of eighteen (18) 24" x 24" x 4" thick precast pads.

$16.50(**)/pier x 18 piers = $297.00

2. **Insulation for skirting cost:**

A. Cost for installing 1½" thick extruded polystyrene insulation behind skirting.

Insulation Cost	=	$1.37 per linear ft.
Labor Cost	=	$1.56 per linear ft.(**)
Cost	=	$2.93 per linear ft.

Total Cost = $2.93/ft. x 180 ft. = $527.40

B. Cost for installing 2" thick extruded polystyrene insulation behind skirting.

Insulation Cost	=	$1.88 per linear ft.
Labor Cost	=	$1.56 per linear ft.(**)
Cost	=	$3.44 per linear ft.

Total Cost = $3.44/ft. x 180 ft. = $619.20

3. Total cost of shallow footings plus insulated skirting (as described in 1.B.):

A. Total cost of shallow strip footing with 1½" extruded polystyrene insulation (as described in 2.A.) behind skirting.

Total Cost = $490.00 + $527.40 = $1017.40

B. Total cost of shallow strip footing (as described in 1.B.) with 2" extruded polystyrene insulation (as described in 2.B.) behind skirting.

Total Cost = $490.00 + $619.20 = $1109.20

C. Total cost of shallow precast footing (as described in 1.C.) with 1½" extruded polystyrene insulation (as described in 2.A.) behind skirting.

Total Cost = $297.00 + $527.40 = $824.40

D. Total cost of shallow precast footing (as described in 1.C.) with 2" extruded polystyrene insulation (as described in 2.B.) behind skirting.

Total Cost = $297.00 + $619.20 = $916.20

Footing Below Frost Cost (1.A) $990.00	vs.	Strip Footing (1.B) with 1½" Insulation (2.A) $1017.40
Footing Below Frost Cost (1.A) $990.00	vs.	Strip Footing (1.B) with 2" Insulation (2.B) $1109.20
Footing Below Frost Cost (1.A) $990.00	vs.	Pad Footing (1.C) with 1½" Insulation (2.A) $824.40
Footing Below Frost Cost (1.A) $990.00	vs.	Pad Footing (1.C) with 2" Insulation (2.B) $916.20

The cost of insulated skirting with 1½" or 2" of insulation in combination with shallow footings would be in the same or slightly less cost range as the footings below frost. This in combination with the warmer temperatures under the home which could reduce the potential of frozen water lines and would help with heat loss through the floor, makes the shallow footing with insulated skirting a viable option.

4. Power vent vs. thermo vents:

A. Total cost for installing a power vent with a relief vent.

One power vent	=	$ 93.02
One humidistat control	=	$ 49.98
One relief vent	=	$ 5.25
Miscellaneous parts	=	$ 15.75
Labor	=	$ 60.00(**)
Total Cost	=	$224.00

B. Total cost for installing four (4) thermo vents (temperature controlled for opening and closing).

Four vents	=	$ 49.00
Labor	=	$ 75.00(**)
Total Cost	=	$124.00

The cost of four (4) thermo vents is $100.00 less than the power vent plus no electricity is used for operation. Since the ventilation results of both systems was basically the same, it is our recommendation that the system with four (4) thermo vents be used.

(*) Cost figures obtained from dealer in Midland, Michigan.
(**) Using a labor cost of $15.00 per hour.

Recommendations

1. Method No. 1 with footings below frost depth is widely accepted and requires no additional study for use with manufactured homes.

2. Method No. 2 with shallow footings placed on well drained non-frost-susceptible soil has been used and approved in various states. Therefore it is recommended that MHI work with local jurisdictions to determine what areas and under what conditions this method can be used. This method has been widely accepted in manufactured housing communities for many years.

3. Method No. 3 with insulated skirting was investigated through testing during the winters of 1994-1995 and 1995-1996 and found to be a viable alternative to footings below frost depth. Even though the cost of installation is slightly higher than footings below frost, the benefits of a non-freezing temperature under the home with less heat loss may be beneficial. It is recommended that insulation thickness and configuration shown in Tables 1 and 2 and Figures 9 and 10 be used unless further study is done to determine if thinner insulation could be used. Further study needs to be done to eliminate the possible bowing of insulation and skirting in locations where large displacements are encountered from frost heave at the edge of the home.

4. Method No. 4 with horizontal insulation placed under and around all footings would cost from $200.00 to $500.00 more than footings below frost depth and would not produce the advantage of warmer under floor space. Therefore it is recommended that no further study of this method be done.

5. It is recommended that thermo vents (vents containing a temperature actuated opening device) be used to ventilate the under floor space of manufactured homes. These vents will produce a positive ventilation of the under floor space and will be closed during freezing temperatures with no requirement that the home owner take any action.

6. It is recommended that further study be done of the actual movement of homes placed on shallow footings with standard skirting. The effects of various conditions under the home (no skirt ventilation, dryer vents ducted to under floor space, heat loss through floor) need to be monitored and compared to determine their effects.

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FEB 19 2001

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February 15, 2002

Ohio Manufactured Housing Association
201 Bradenton Avenue, Suite 100
Dublin, Ohio 43017

Attn: Tim Williams
Executive Vice President

Re: Report on Alternate Base Support Systems for Manufactured Housing in Ohio
Three test sites in Central Ohio

Dear Mr. Williams,

Following is a report on two home test sites in Circleville Ohio, Pickaway County and one in Lancaster, Fairfield County. The test program was authorized by OMHA in February 1998 in cooperation with the Ohio Department of Health (ODH) to study the effectiveness of foundation systems used to support manufactured housing in Ohio.

CONCLUSIONS

The three Central Ohio sites were instrumented and data collected from July 2000 through November 2001 and are the third set of sites for which data have been collected.

For the conditions encountered during the test period, both the concrete pad foundations and ABS pad foundation system tested were satisfactory.

Uninsulated vinyl skirting with small vent holes are effective in keeping the crawl space temperatures moderate so that the ground does not freeze under the home and temperature of the floor remains comfortable inside the home.

FOUNDATION SYSTEMS and TEST DATES

Home #1, at 186 Deerborn Court in Lancaster, was provided with continuous concrete ribbons 24 inches wide by 4.5 inches deep for the length of the home.
Dates tested: Sept. 1, 2000 to Aug. 31, 2001.

Home #2, at 56 Evergreen Avenue in Circleville, was provided with individual ABS pads for each pier. Pads are 16 inches square, flat on the bottom, and ribbed above designed to support concrete block piers. The ABS pads are made of plastic with high impact resistance, and a flexural strength over 8,900 psi. More detailed information, including load test data, is available from the supplier, Manufactured Housing Foundation Systems of San Marcos, CA.
Dates tested: Nov. 9, 2000 to Nov. 30, 2001.

Home #3 at 234 Parklawn in Circleville, was provided with a continuous concrete pad, the approximate size of the home, 4 inches thick under the home.
Dates tested: Oct. 1, 2000 to September 30, 2001.

DISCUSSION

Instrumentation

Each home was instrumented to measure the vertical movement at one location to an accuracy of about 1/200 of an inch. Thermocouples were placed to measure the outside air temperature as well as temperature of air inside each home and air temperature under the home (crawl space). Also measured was the ground temperatures at two locations at depths of 6, 12 18 and 24 inches (soil probes). One location is near the outside skirting and one near the foundations.

The equipment stopped recording temperatures at certain times, so no data are available for stretches of a month or two until the instruments were restarted and recalibrated. The instruments for recording movement similarly stopped recording at the same times. Consistency of the disruption of all instruments within each home but not between homes indicates these stoppages were likely due to a problem with the data recording instruments and not the probes and thermocouples themselves. Progressive Engineering reports that the recalibration represents values that would have been recorded had the disruption not occurred and that values during the disruptions can be fairly represented by the values before and after.

In other words, the missing data does not mask a significant problem that would have otherwise been reported. This conclusion is confirmed by the consistency of data and by the performance of the homes themselves.

Temperature Records

The National Climatic Data Center (NOAA) for the Columbus Airport indicates that December 2000 continuing into January 2001 had 21 consecutive days with the average temperature below freezing with a low temperature of one degree F. After a "warm spell" in which the temperatures rose to as high as 38 to 40 degrees, January 2001 had an additional 10 consecutive days of average temperatures below freezing with a low temperature of 18 degrees.

Despite the separation between home sites and the Columbus Airport, Progressive Engineering reported outside air temperatures similar to, although somewhat less extreme, than NOAA, probably due in part to the fact that NOAA recorded temperatures hourly whereas Progressive Engineering recorded temperatures every 6 hours. Thus NOAA was more likely to catch the extreme temperatures. See Appendices A3.4, A3.5, and A3.6.

Despite long periods of below freezing temperatures, the ground did not freeze under Home #1. Soil probe temperatures were in the low 60s in September, October and November and the low 40s in December, January, and February, then rising to around 70 degrees in June and July.

In Home #2, except for two errant probes, the soil probe temperatures were in the high 30s in January and February until a recalibration gave all probe temperatures in the low 40s until April. After a gap of missing data, all probes gave soil temperatures around 70 degrees from mid-June until the end of the test.

In Home #3 soil probe temperatures were in the low 60s in October and November. After a gap of missing data, soil probe temperatures were around 40 degrees from late January to early May. After another gap of missing data, soil probe temperatures were in the high 60s from late June until September.

Inside air temperatures indicate the living habits of the occupants with temperatures in the mid to high 70s in the winter heating season, low 70s when the home was presumably not occupied, and high 60s in the summer air-conditioning season.

Under Home #1, air temperature in the crawl spaces measured by Progressive Engineering was not as extreme as outside air temperatures, as might be expected, and reached a low of 41 degrees. In March, April, and early May crawl space temperatures fluctuated up and down by 15 to 20 degrees on a four or five day cycle. Apparently, a portion of the skirting was removed for unexplained reasons and then replaced leading to the measured swings in temperature. It is also possible that the recording instrument was malfunctioning.

Data on crawl space temperatures under Home #2 are not available due to a limitation of capacity of the data recording equipment.

Crawl space temperatures under Home #3 were fairly steady in the 60s in October and November and in the 40s in March, April and May, rising to nearly 70 degrees in June, July and August.

Movement

Of primary concern is settlement or heaving of the foundations because such movement, if sufficiently large, could break utility connections. If the movement were differential between foundations, it could cause doors and windows in the home to jam.

For Home #1, during the test period, the maximum movement of the footings tested was downward 0.07" or about 1/16 inch. Movement of the footing was remarkable steady, trending downward toward the end of the test period. Since there were gaps in the measurements in May and early June of 2001, and from late July to the end of August, it is possible that the settlement is overstated by 0.02 inches, which is a trivial amount.

For Home #2, during the test period, the movement started trending downward after a gap of missing data in November and most of December, reaching a maximum settlement of 0.05 inches by mid April 2001. Following another gap of missing data from early April until the end of June, the instrument was recalibrated to show a settlement of 0.225 (1/4) inches that gradually decreased to a settlement of 0.16 (3/16) inches at the end of November. It appears the recalibration overstated the settlement by a factor of four or five.

For Home #3, during the test period, movement hovered around zero (plus or minus 0.005 inches) until a gap of missing data from the end of November to the end of January 2001. The instrument was then recalibrated to show a settlement of about 0.11 (1/8)

inches that held steady until early May 2001. After another gap of missing data, the instrument was recalibrated in mid June at a settlement of 0.08 (1/16) inches that held steady until the end of the test period.

Soils under all three homes did not heave in the winter but allowed the homes to continue to settle slightly. In open air away from a heat source, the ground would have frozen in December-January and frost-susceptible soils probably would have heaved. No heaving was measured during the test period for the subject homes.

In fact, some slight settlement was indicated by the gages, probably due to shrinkage of the wood shims on top of the concrete block piers as a result of a lower humidity during the winter in the crawl space, or perhaps due to a gradual shrinkage of the foundation soils.

It is conservatively estimated that homes could sustain a uniform settlement or heaving of ten times the amount experienced, or differential settlement between adjacent footings of five times the amount experienced, all without noticeable distress. Therefore, the measured movement is not cause for concern.

Examination of the homes after the tests were completed and interviews with the occupants and maintenance personnel indicates that no problems occurred as a result of foundation movement. See Appendix A2.4.

Skirting

All three homes were fully skirted with built-in venting. Exhausts from the homes were reportedly not vented below them to the crawl space. However, Progressive Engineering also reports that a dryer exhaust was vented to the crawl space in Home #1 in Lancaster.

DATA PRESENTATION

The test program is outlined in "Proposed ODH/OMHA Joint Test Study" in Appendix A1 in the report dated November 4, 1999 on the Hamilton County test site, and is not repeated here.

Requested data collection by Home Vendor is contained in the Questionnaire in Appendix A2 in the report dated November 4, 1999 on the Hamilton County test site, and is not repeated here. The data for the Central Ohio test sites are summarized in Appendix A2.4 contained herein.

Weather records for the Central Ohio area were obtained from the National Oceanic and Atmospheric Administration (NOAA) in Ashville, North Carolina. Temperatures from NOAA and from Progressive Engineering are summarized in Appendix A3.4 for Home #1, A3.5 for Home #2 and A3.6 for Home #3.

Progressive Engineering Inc. of Goshen, Indiana was retained to place the instrumentation, record the data and prepare final reports on the data. Their reports are contained in separate documents.

Respectfully submitted,

Russell S. Fling

Russell S. Fling, P.E.

file: 169-17

Appendix A2.4

(Appendix numbers are not continuous because they are coordinated with the first report dated November 4, 1999 and the second report dated June 29, 2000.)

Summary of data from Data Collection Form for Home sites in Circleville and Lancaster, Ohio.

Home #1 is at 186 Deerborn Court, Lancaster, Ohio, and is a 14 ft by 67 ft home.
Home #2 is at 56 Green Avenue, Circleville Ohio, and is a 14 ft by 66 ft home.
Home #3 is at 234 Parklawn, Circleville Ohio, and is a 16 ft by 76 ft home.

The Vendor is Elsea Home Center, 2015 Stoneridge Drive, Circleville, Ohio 43113.

Q1.1 Type of foundation pads?

Home #1	Longitudinal concrete ribbons 24" x 4½" x 66 ft.
Home #2	Individual ABS pads 16" square
Home #3	Concrete pad 10'6" x 75' x 4" with #4 rebar @12"c/c longitudinally

Type of piers?

Home #1	2 high concrete block 8"x8"x16" plus wood shims – 18" high
Home #2	2 to 2½ high double concrete block 8"x8"x16" (16" square pier) plus wood shims – 18" high.
Home #3	2 high concrete block 8"x8"x16" plus wood shims – 22" high.

Number of piers?
For all three homes:
Two piers across width of home, under steel beams.
Piers spaced about 8 ft c/c lengthwise typically (range of 5½ ft. to 12 ft).
For exact location, see sketches in Progressive Engineering's reports.

Q1.2 Height of crawl space?
Determined by number of concrete block in piers, plus the steel beams.
About 2'6" for homes #1 and #3.
About 2'6" to 2'11" for home #2, depending on location.

Q1.3 Type of skirting?
For all three homes, vertical corrugated vinyl siding.
No insulation.

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Q1.4 How were truck and homes maneuvered over the site?

All three homes were backed onto site so that the tractor did not pass over the foundation.. Home #2 was in place before placing the ABS pads but concrete pads were in place before placing homes #1 and #3.

Q1.4.2 Dead weight of homes?

Home #1 weight equals 17 to 22 tons approx.
Home #2, weight equals 42,730 lbs. (21+ tons)
Home #3, weight equals about 15 to 18 tons.

Q1.4.6 Number of axles under homes during delivery?

For Home #1, the number of axles is unknown.
For Home #2, two axles were used.
For Home #3, four axles with leaf springs were used.

Q1.4.7 Were equalizers used? No

Q1.4.8 Pads used to protect the foundation system? None used.

Q1.4.9 Soil elevation in vicinity of home?

For Home #1, level from east to west (along length of home) and gently sloping from south down to the north.
For Home #2, approximately level
For Home #3, very level

Q1.5 Description of soils.

Home #1, Topsoil was removed, gravel sub-base on clay soils.
Home #2 and #3, Topsoil was removed. Site was not cut or filled. Clay soil base. Site was used for farming more than 30 years ago. Park was developed prior to 1970. An old airstrip is nearby.
No soils investigation report is available for the three sites.

Q1.6 Site grading slope?

Home #1, grade slopes gently away from the home, to the north.
Home #2 grade around home is approximately level.
Home #3 grade around home is approximately level.

Q1.7 Venting of crawl space?

For all three homes, construction of the skirting provides numerous, closely spaced, small vents.
Vents are open all the time. Dryer vents are reportedly ducted to the outside, not to the crawl space, although Progressive Engineering reports the dryer vent was ducted to the crawl space in home #1 in Lancaster.

Q1.8 Was a vapor barrier used? For all three homes, No.

Q1.9 Wind protection?

Home #1, A nearby high hill with trees affords some wind protection on the south and east sides. On the north and west sides, very little wind protection, consisting of a few small trees and other nearby homes. Low hills 300 to 500 ft away would not provide wind protection.

Home #2, Very little, consisting of a few small trees and other nearby homes.

Home #3, Very little, consisting of a few small trees and other nearby homes.

Q1.10 Do all doors operate freely?

For all three homes, when homes were installed, all doors operated satisfactorily. No other problems with doors, windows or other portions of the homes were reported.

Q1.11 Location of instruments?

At all three homes, instruments are located near the back end. Ground temperature probes were placed just outside the skirting and next to the pier foundations. See Progressive Engineering's report for exact location.

Q2.5 Air temperature inside homes?

Temperatures were recorded and reported by Progressive Engineering.

For Home #1, reported temperatures are as might be expected in an occupied home.

For Home #2, data not available.

For Home #3, reported temperatures are as might be expected in an occupied home.

Q2.6 Frost depth?

At Home #1, Progressive Engineering reports the ground temperature did not go below freezing.

At Home #2, Progressive Engineering reports the ground temperature did not go below freezing.

At Home #3, Progressive Engineering reports the ground temperature did not go below freezing.

Q3 Performance reports after completion of the Test Study

Q3.1 Have difficulty with doors?

All three homes: No.

Q3.2 Have difficulty with windows?

All three homes: No.

Q3.3 Have difficulty with utility connections?

All three homes: No.

Q3.4 Any other problem?

All three homes: No.

15

Appendix A3.4 for Home #1 (186 Deerborn Ct. Lancaster OH)

1) Summary of temperature records at Columbus Airport
Reported by: NOAA, National Climate Data Center – repeated in Appendices A3.5 and A3.6.
2) And temperature records at test site for Home #1
Reported by: Progressive Engineering, Inc. (Figures in parenthesis)

Only temperatures at or below freezing are summarized

Month	No. of Days min. temp. at or below freezing	No. of Days average temp. at or below freezing (a)	Max. No. of consecutive days ave. temp. at or below freezing	Minimum daily temp. Degrees	Min. average daily temperature (b) Degrees
9/00					
10/00	3 (2)			31 (30)	
11/00	14 (12)	5 (5)	4 (4)	15 (16)	23
12/00	29 (28)	28 (27)	21 (18) (d)	1 (2) (c)	0 (c)
1/01	28 (27)	21 (17)	10 (10)	6 (10)	15
2/01	20 (16)	9 (9)	2 (2)	14 (15)	21
3/01	18 (14)	8 (8)	5 (5)	13 (15)	21
4/01	3 (2)			28 (27)	
5/01					
6/01					
7/01					
6/01					
9/01					

(a) Data for Progressive Engineering are an interpolation of the graphs provided.
(b) Minimum average temperatures not reported by Progressive Engineering.
(c) This is an apparent discrepancy in NOAA data for December 22 and 23 in which the average temperature is lower than the minimum temperature.
(d) Includes the first 6 days in January for NOAA records and the first 3 days for Progressive Engineering records.

15

Appendix A3.5 for Home #2 (56 Evergreen Ave. Circleville, OH)

1) Summary of temperature records at Columbus Airport
Reported by: NOAA, National Climate Data Center – repeated in Appendices A3.4 and A3.6.
2) And temperature records at test site for Home #2
Reported by: Progressive Engineering, Inc. (Figures in parenthesis)

Only temperatures at or below freezing are summarized

Month	No. of Days min. temp. at or below freezing	No. of Days average temp. at or below freezing (a)	Max. No. of consecutive days ave. temp. at or below freezing	Minimum daily temp. Degrees	Min. average daily temperature (b) Degrees
11/00	14 (11)	5 (5)	4 (3)	15 (16)	23
12/00	29 (28)	28 (25)	21 (14) (d)	1 (3) (c)	0 (c)
1/01	28 (26)	21 (16)	10 (10)	6 (11)	15
2/01	20 (16)	9 (9)	2 (2)	14 (15)	21
3/01	18 (14)	8 (8)	5 (3)	13 (15)	21
4/01	3 (2)			28 (27)	
5/01					
6/01					
7/01					
8/01					
9/01					
10/01	2 (0)			32	
11/01	2 (2)			30 (30)	

(a) Data for Progressive Engineering are an interpolation of the graphs provided.
(b) Minimum average temperatures not reported by Progressive Engineering.
(c) This is an apparent discrepancy in NOAA data for December 22 and 23 in which the average temperature is lower than the minimum temperature.
(d) Includes the first 6 days in January for NOAA records.

15

Appendix A3.6 for Home #3 (234 Parklawn, Circleville, OH)

1) Summary of temperature records at Columbus Airport
Reported by: NOAA, National Climate Data Center – repeated in Appendices A3.4 and A3.5.
2) And temperature records at test site for Home #3
Reported by: Progressive Engineering, Inc. (Figures in parenthesis)

Only temperatures at or below freezing are summarized

Month	No. of Days min. temp. at or below freezing	No. of Days average temp. at or below freezing (a)	Max. No. of consecutive days ave. temp. at or below freezing	Minimum daily temp. Degrees	Min. average daily temperature (b) Degrees
9/00					
10/00	3 (3)			31 (31)	
11/00	14 (13)	5 (6)	4 (4)	15 (16)	23
12/00	29 (29)	28 (26)	21 (18) (d)	1 (c)	0 (c)
1/01	28 (27)	21 (17)	10 (10)	6 (10)	15
2/01	20 (17)	9 (9)	2 (2)	14 (15)	21
3/01	18 (15)	8 (8)	5 (5)	13 (16)	21
4/01	3 (2)			28 (27)	
5/01					
6/01					
7/01					
8/01					
9/01					

(a) Data for Progressive Engineering are an interpolation of the graphs provided.
(b) Minimum average temperatures not reported by Progressive Engineering.
(c) This is an apparent discrepancy in NOAA data for December 22 and 23 in which the average temperature is lower than the minimum temperature.
(d) Includes the first 6 days in January for NOAA records and the first 3 days for Progressive Engineering records.

.15

PE

PROGRESSIVE ENGINEERING, INC.
Architectural • Engineering • Review Agency • Surveying • Testing

58640 STATE ROAD 15
GOSHEN, INDIANA 46528
Telephone (219) 533-0337
Fax (219) 533-9736

Ohio Manufactured Housing Association

Manufactured Home Movement

Field Tests at
Lancaster, OH

July 2000 through July 2001

This test report contains forty-Four (44) pages, including the cover sheet. Any additions to, alterations of, or unauthorized use of excerpts from this report are expressly forbidden.

98-390
(Lancaster)

15

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1 thru 2	Written Test Description
3 thru 14	Measured Temperature Graphs
15 thru 27	Measured Movement Graphs
28 thru 38	Probe Temperatures
39	Set-up Drawing
40 thru 42	Pictures of Test Sites

15

1. **TITLE**

Manufactured Home Movement and Frost Penetration Field Test.

2. **TEST OBJECTIVES**

A. Record vertical movement of a manufactured home using concrete runners and dry stack block foundation.

B. Measure the temperatures under, inside and outside of the home.

C. Measure ground temperature just inside skirting and beside runner close to vertical measurement location.

3. **TESTED FOR**

Ohio Manufactured Housing Association
201 Bradenton Avenue, Suite 100
Dublin, OH 43017-3540
Contact: Tim Williams

4. **TESTING ORGANIZATION**

Progressive Engineering, Inc.
58640 State Road 15
Goshen, IN 46528

See BOCA Research Report No. 98-30
See ICBO Research Report No. TL-178
See SBCCI Research Report No. TL-9729
Approved Testing Agency in Ohio by O.B.B.S.

5. **TESTING PERSONNEL**

Director of Testing - Greg A. Weeden
Technician - Shawn Kaufman

6. TEST SITE

One (1) home was tested. It was set on lot #186 in Rustic Ridge located on Tarklin Road, Lancaster, OH.

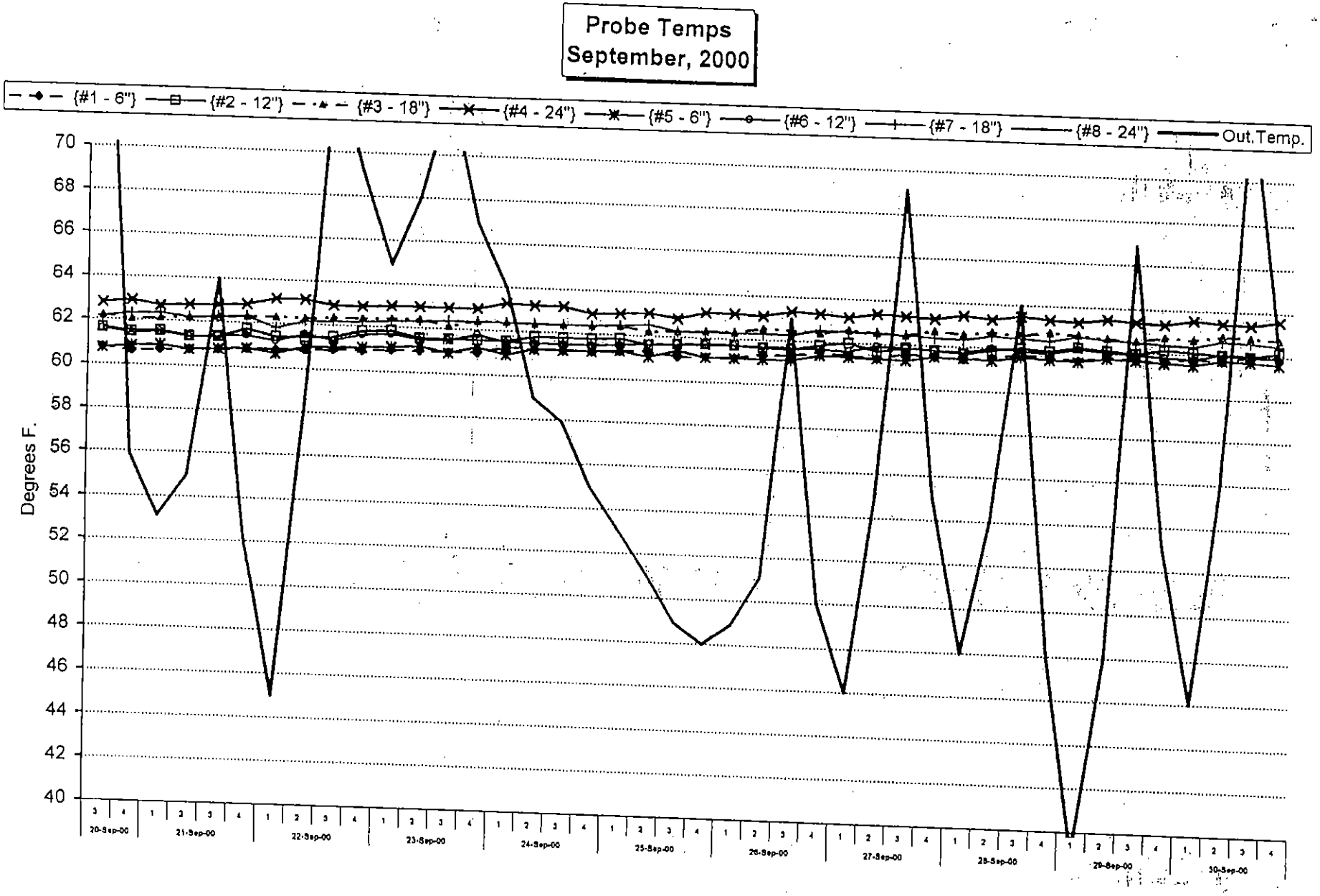
A. Lot #186
B. Size: Approximately 14' x 60' single wide.
C. Skirting: Standard vinyl skirting, all vented pieces.
D. Piers: Single dry stacked blocks setting on runners.
E. Runners: Longitudinal, 23"x3" to 4"thick concrete with tie-downs anchored into them.
F. Owner: Elmer Howard occupied home since May 2000.
G. Soil: Wet clay.

7. HOME SET-UP

The home had already been skirted. The home had no one living there at the time of set-up. A linear transducer was placed at the second pier from the front corner under the home. The pier used for measurement was randomly chosen. The temperature probes were placed under, outside and inside the home. The temperature probes and linear transducer were all wired to an on-site data logger under the home. Temperature probes were also put in the ground at two (2) locations, just inside the skirting and beside the runner. The probes were set 6", 12", 18" and 24" deep into the ground. See the attached drawing for details.

8. RESULTS

The maximum movement measured was a downward .066".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Out.Temp.
Degrees F.
70
68
66
64
62
60
58
56
54
52
50
48
46
44
42
40
20-Sep-00
21-Sep-00
22-Sep-00
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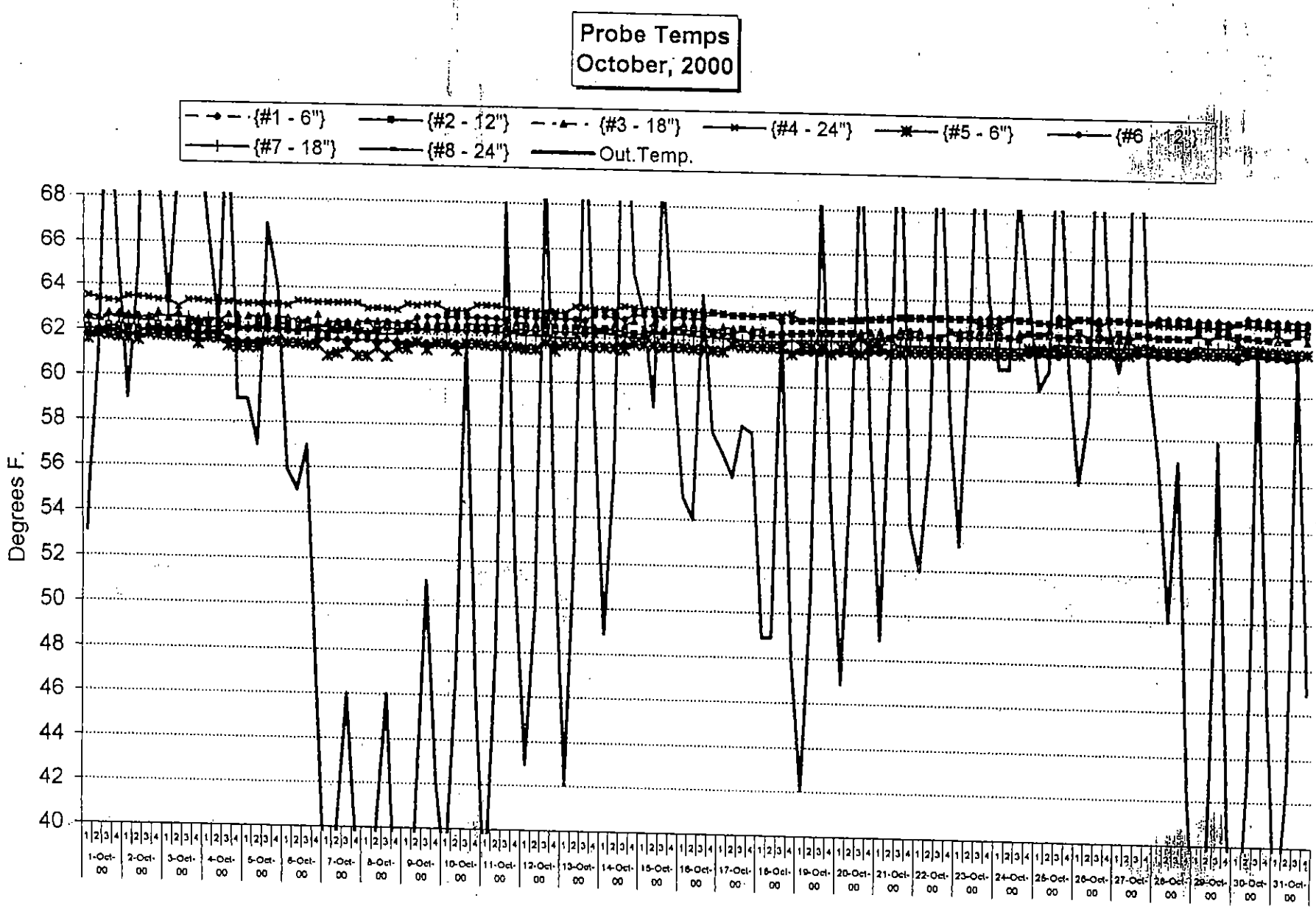
29-Sep-00
30-Sep-00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{#8 - 24"}
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Degrees F.
68
66
64
62
60
58
56
54
52
50
48
46
44
42
40
1-Oct-00
2-Oct-00
3-Oct-00
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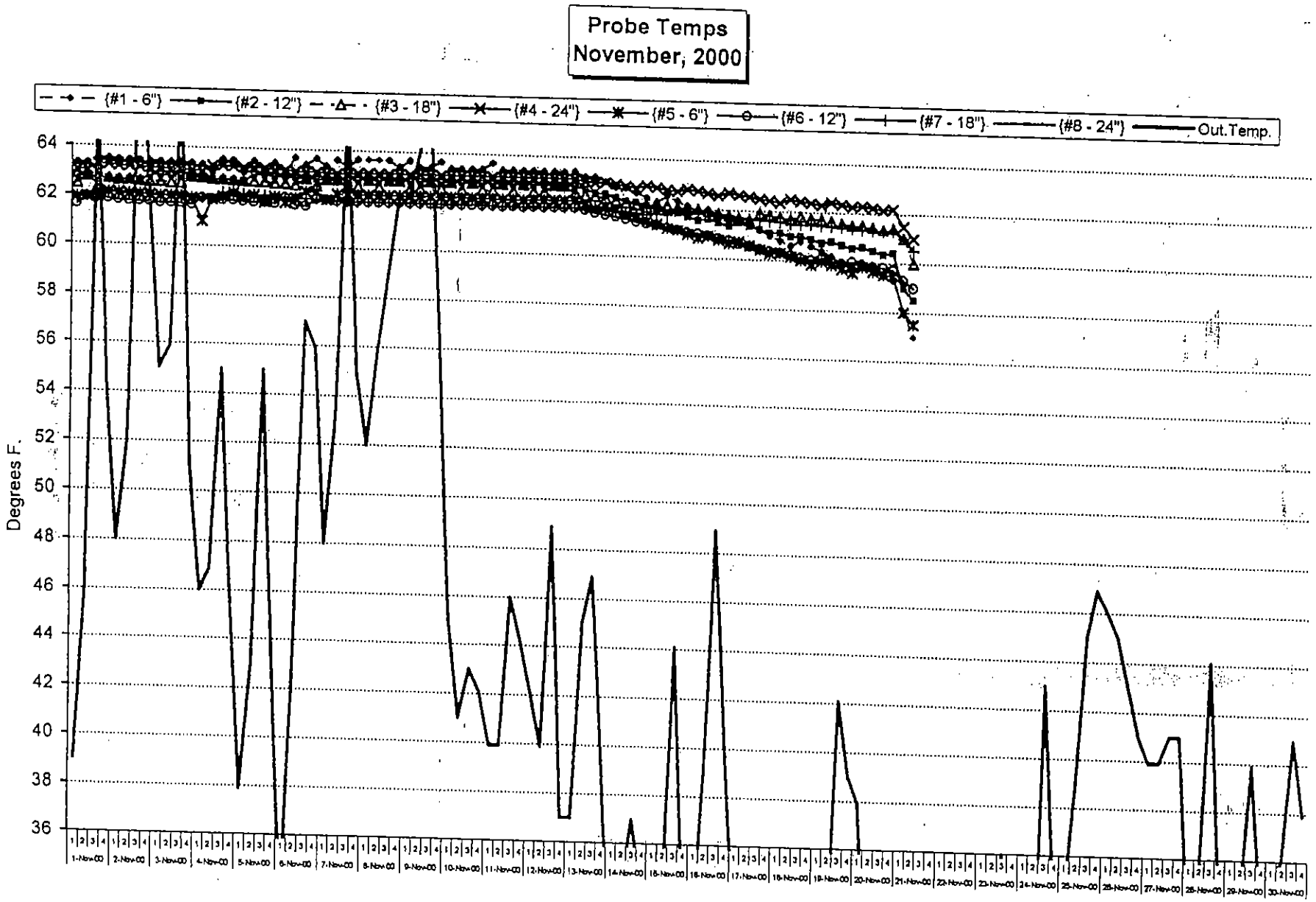
31-Oct-00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{#7 - 18"}
{#8 - 24"}
Out.Temp.
Degrees F.
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
1-Nov-00
2-Nov-00
3-Nov-00
4-Nov-00
5-Nov-00
6-Nov-00
7-Nov-00
8-Nov-00
9-Nov-00
10-Nov-00
11-Nov-00
12-Nov-00
13-Nov-00
14-Nov-00
15-Nov-00
16-Nov-00
17-Nov-00
18-Nov-00
19-Nov-00
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21-Nov-00
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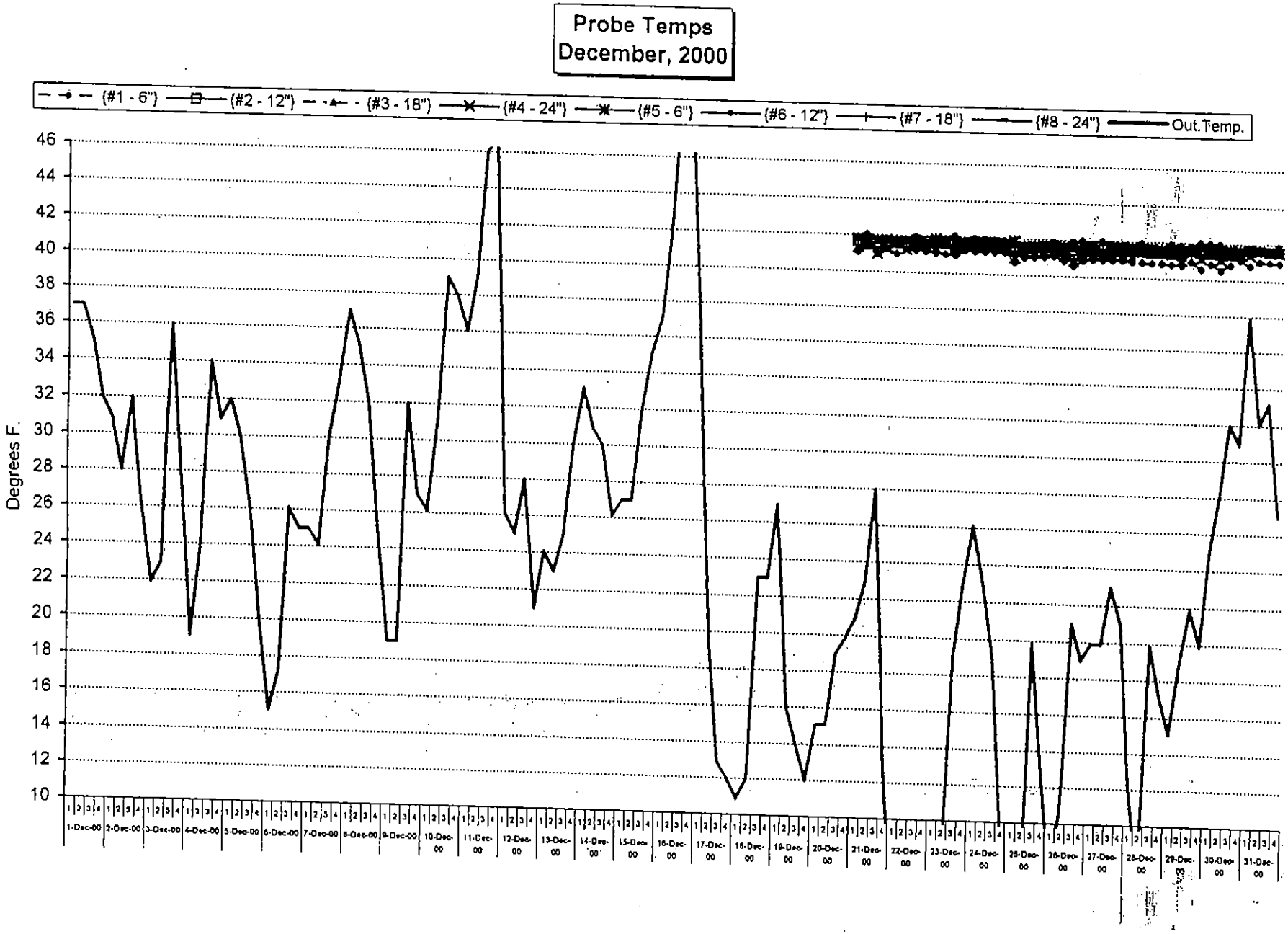
29-Nov-00
30-Nov-00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Degrees F.
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
1-Dec-00
2-Dec-00
3-Dec-00
4-Dec-00
5-Dec-00
6-Dec-00
7-Dec-00
8-Dec-00
9-Dec-00
10-Dec-00
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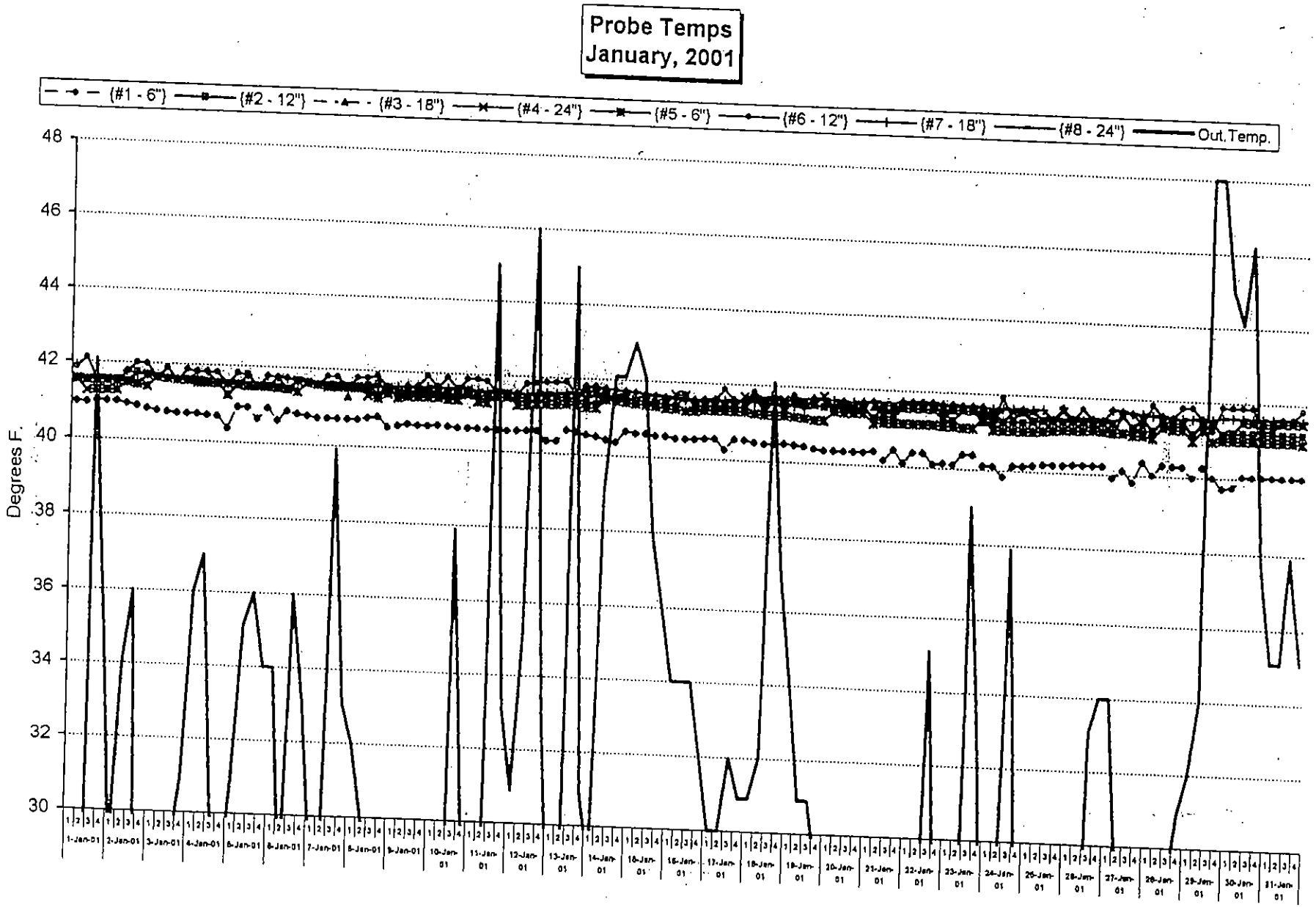
30-Dec-00
31-Dec-00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Out. Temp.
Degrees F.
48
46
44
42
40
38
36
34
32
30
1-Jan-01
2-Jan-01
3-Jan-01
4-Jan-01
5-Jan-01
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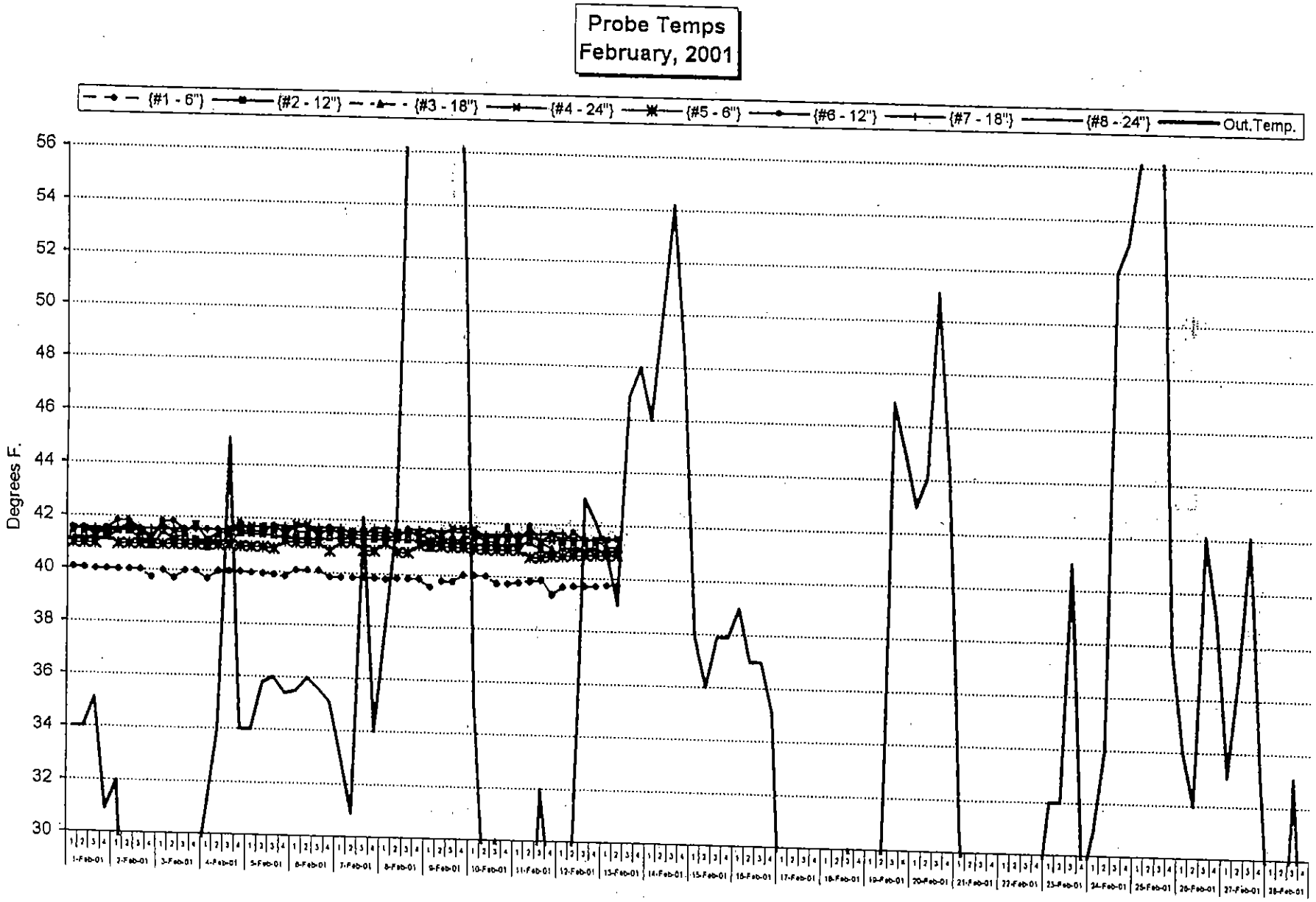
31-Jan-01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{#7 - 18"}
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Out.Temp.
Degrees F.
56
54
52
50
48
46
44
42
40
38
36
34
32
30
1-Feb-01
2-Feb-01
3-Feb-01
4-Feb-01
5-Feb-01
6-Feb-01
7-Feb-01
8-Feb-01
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10-Feb-01
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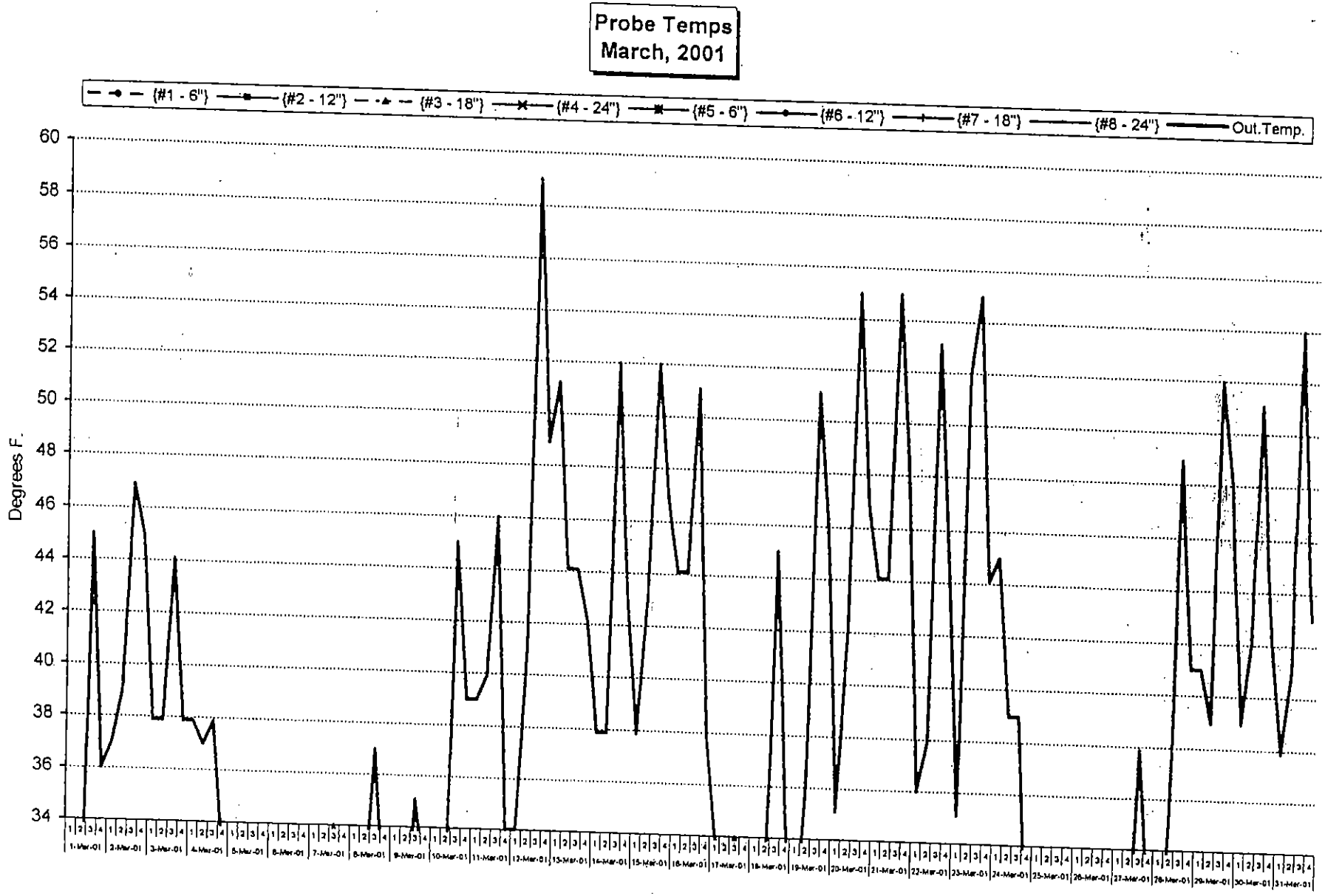
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Degrees F.
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58
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54
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36
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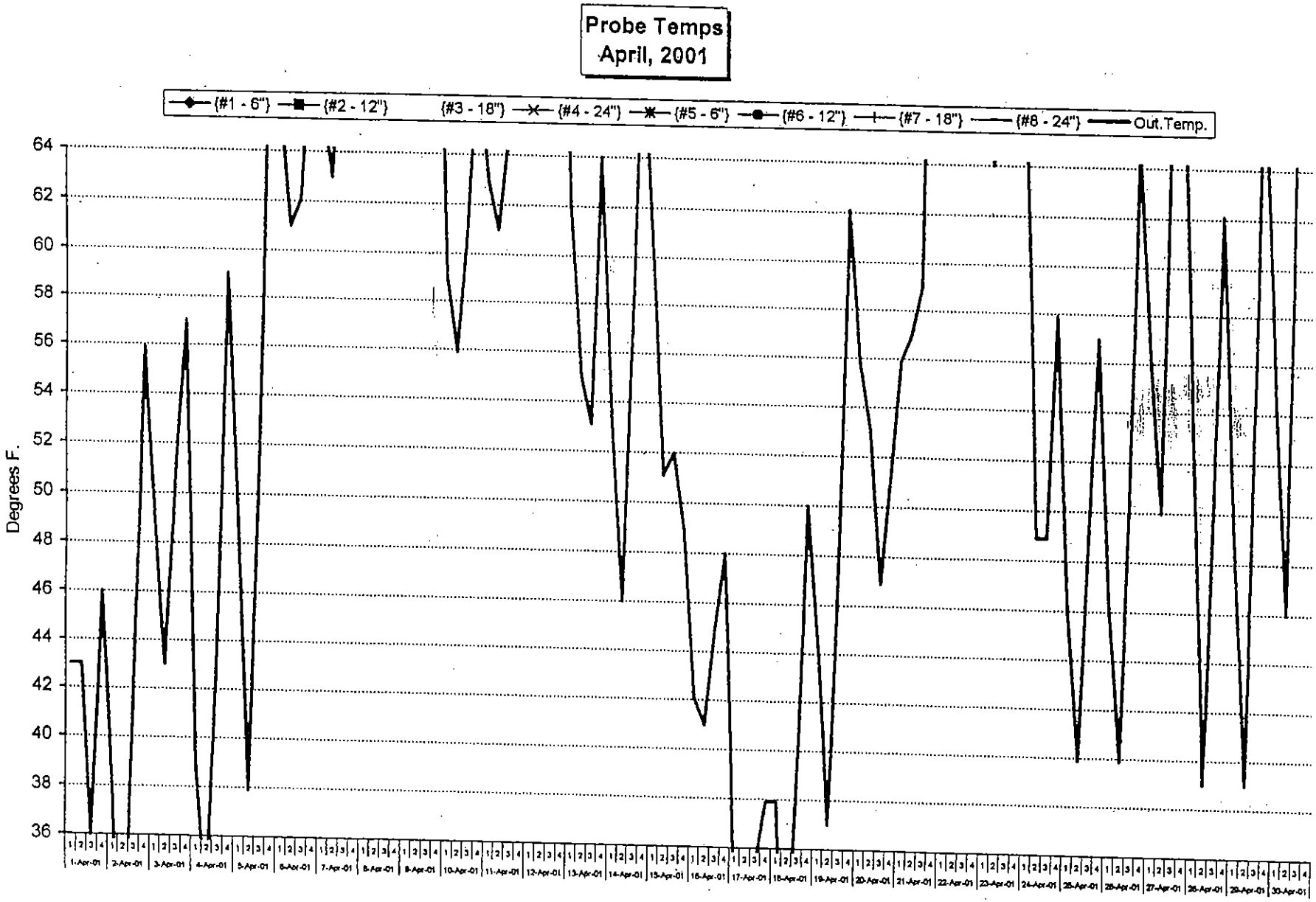
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Out.Temp.
Degrees F.
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
1-Apr-01
2-Apr-01
3-Apr-01
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7-Apr-01
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9-Apr-01
10-Apr-01
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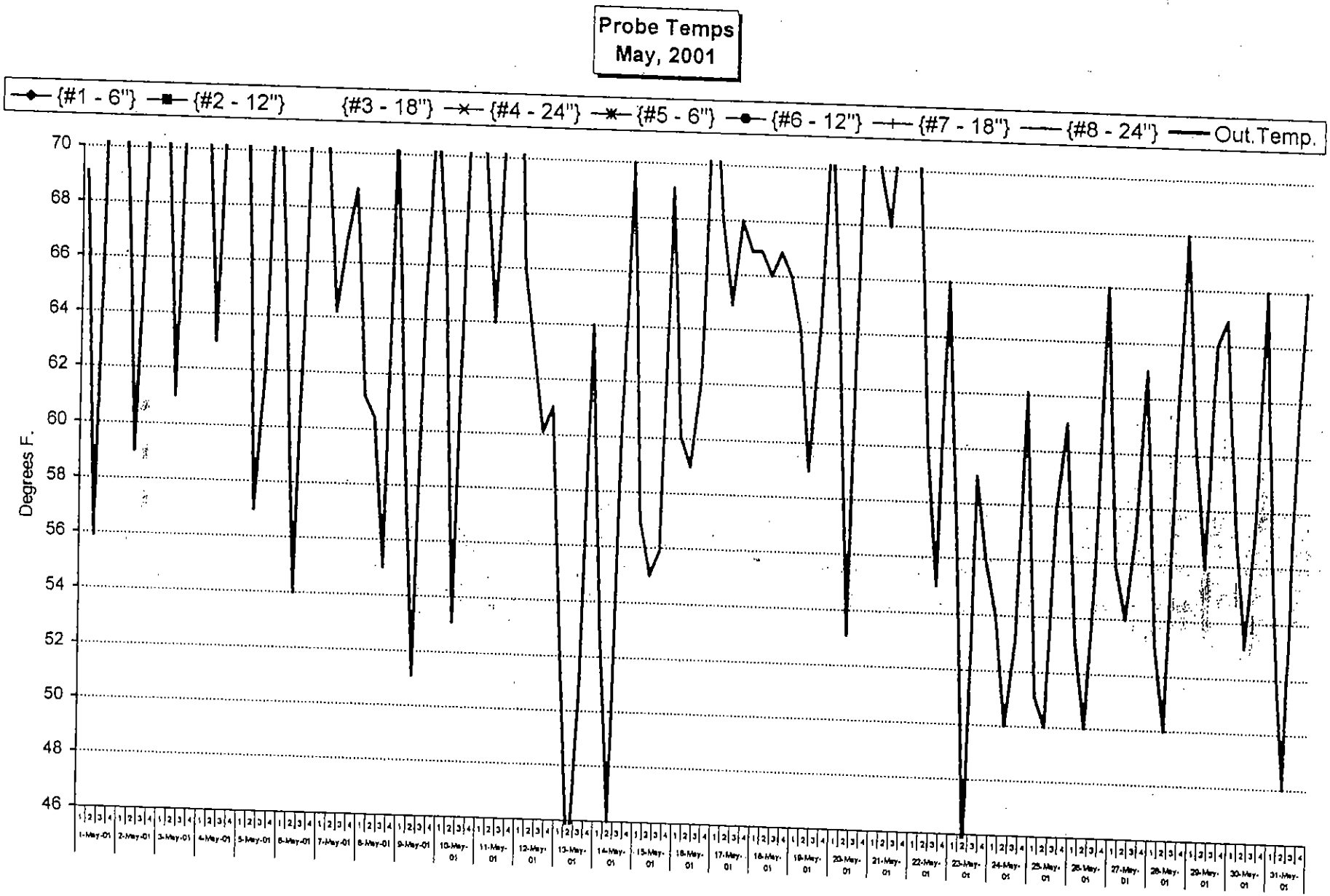
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Out.Temp.
Degrees F.
70
68
66
64
62
60
58
56
54
52
50
48
46
1-May-01
2-May-01
3-May-01
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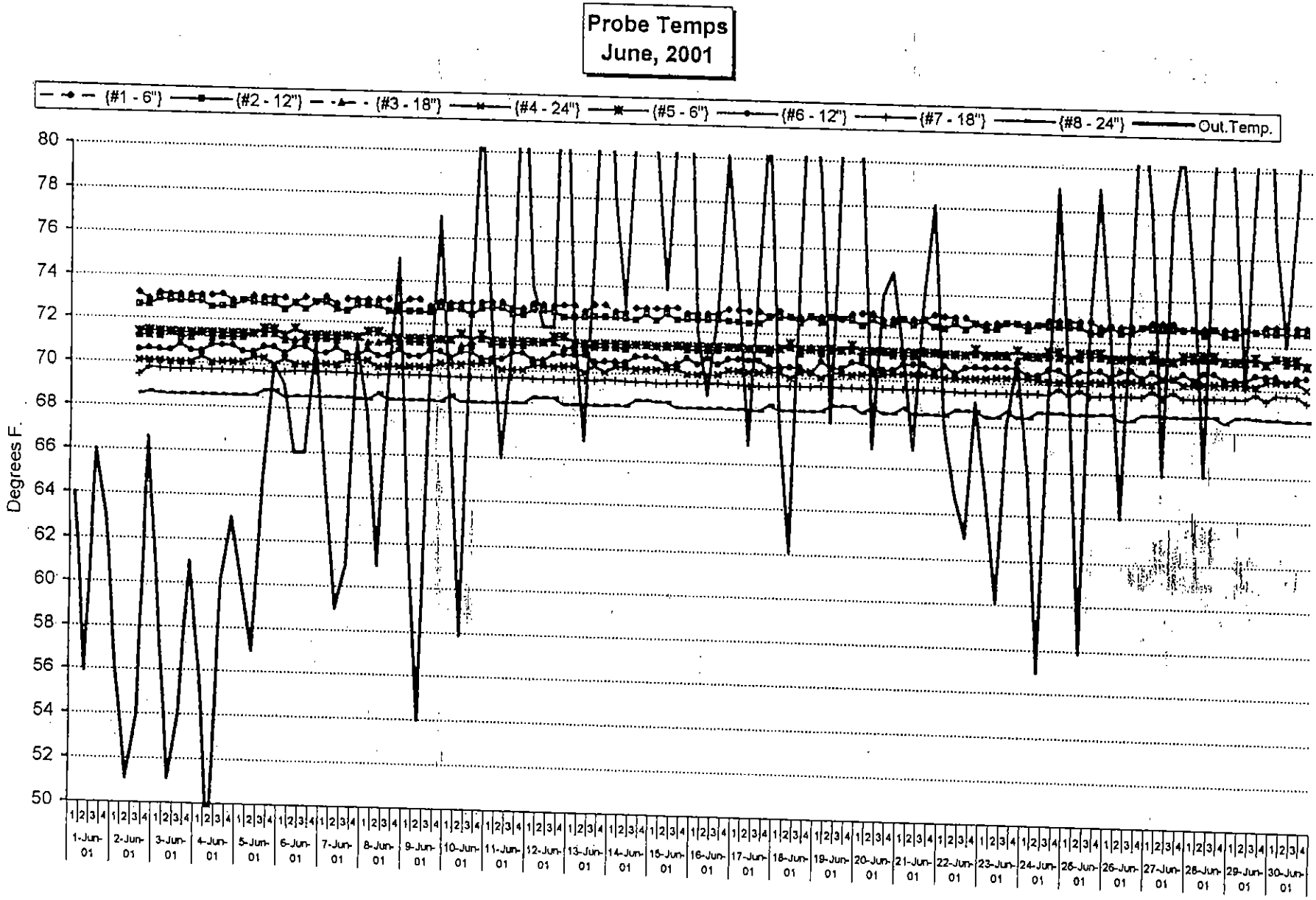
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Out.Temp.
Degrees F.
80
78
76
74
72
70
68
66
64
62
60
58
56
54
52
50
1-Jun-01
2-Jun-01
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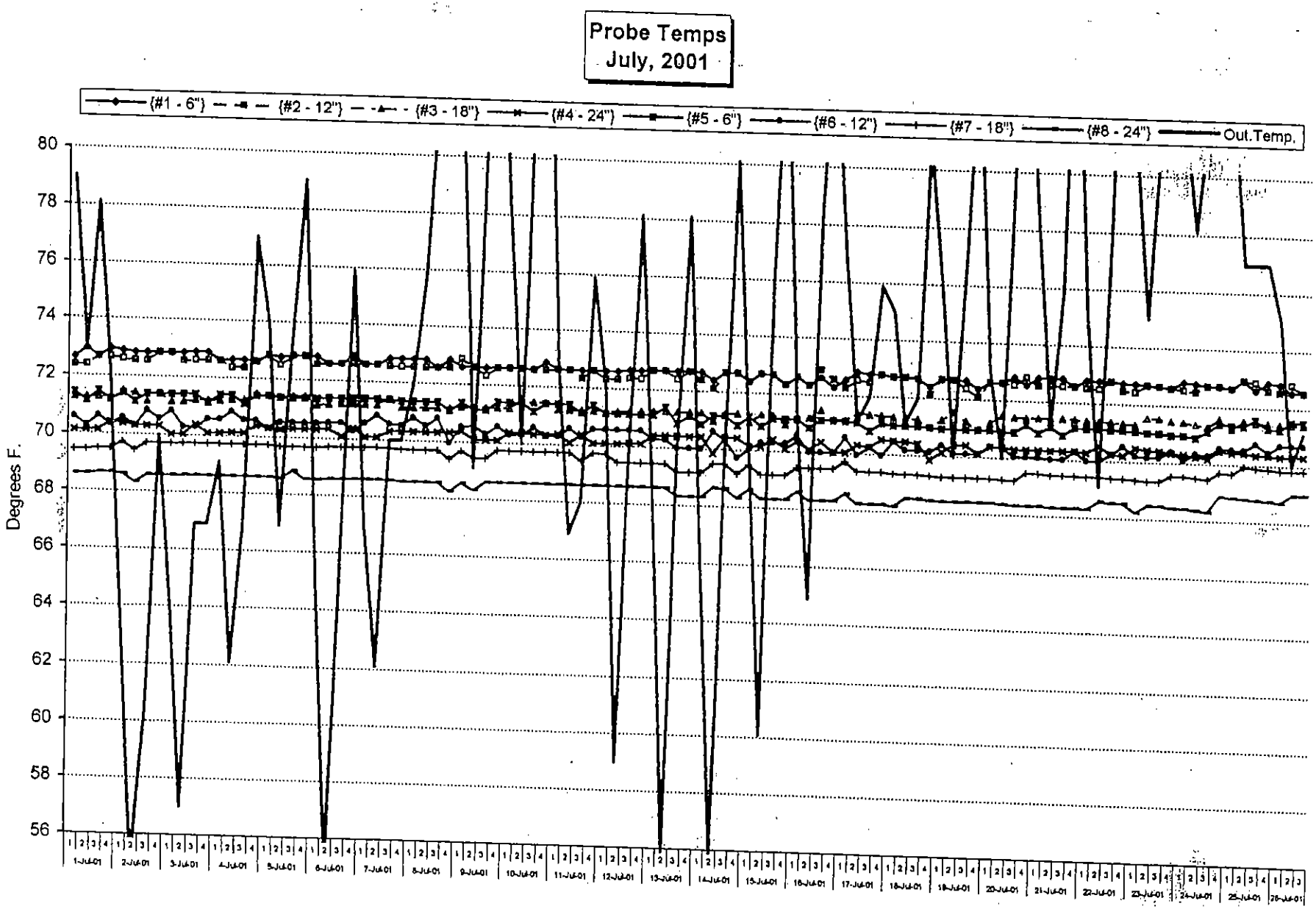
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July, 2001
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{#6 - 12"}
{#7 - 18"}
{#8 - 24"}
Out.Temp.
Degrees F.
80
78
76
74
72
70
68
66
64
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58
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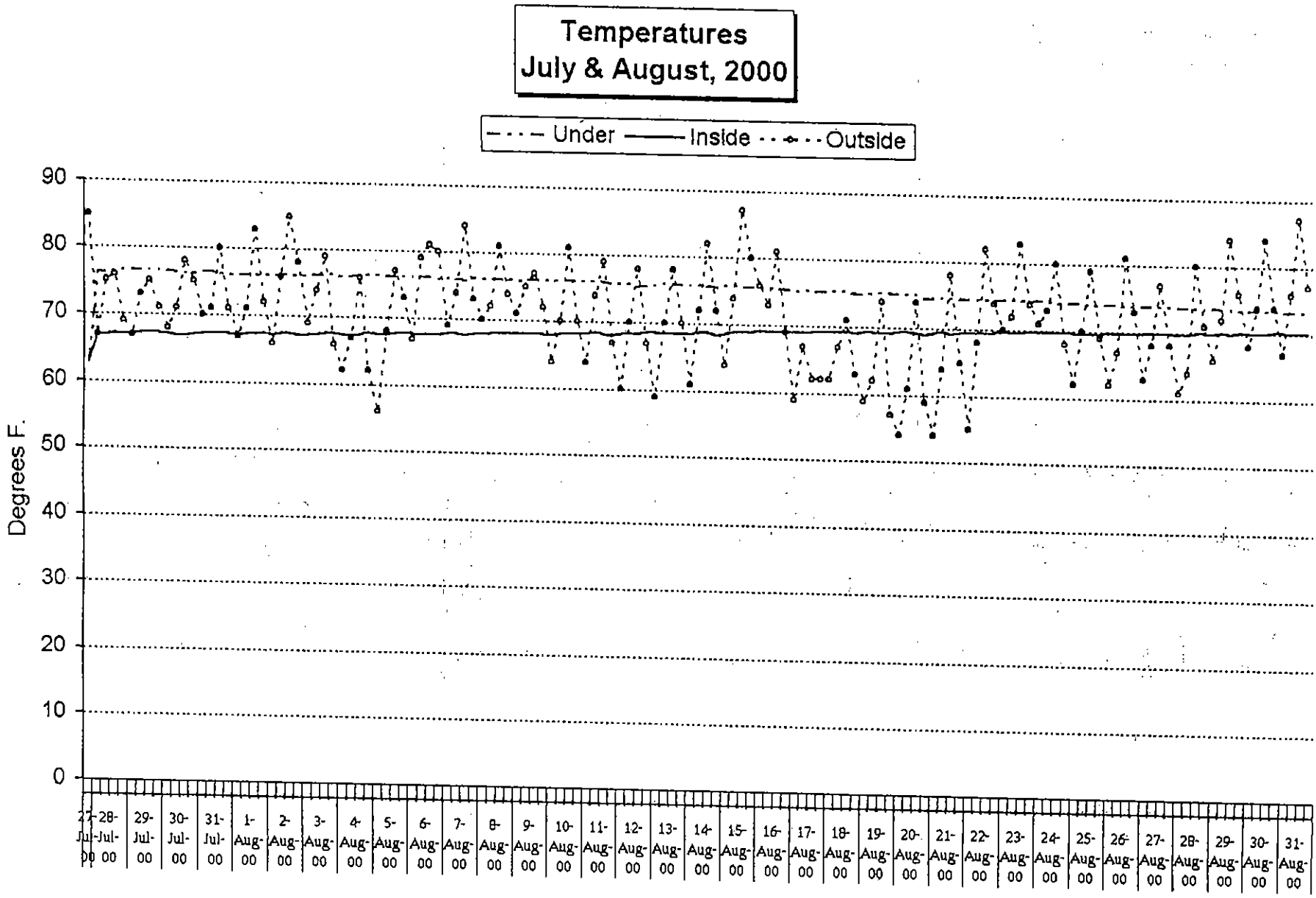
Temperatures
July & August, 2000
Under
Inside
Outside
Degrees F.
90
80
70
60
50
40
30
20
10
0
27-Jul-00
28-Jul-00
29-Jul-00
30-Jul-00
31-Jul-00
1-Aug-00
2-Aug-00
3-Aug-00
4-Aug-00
5-Aug-00
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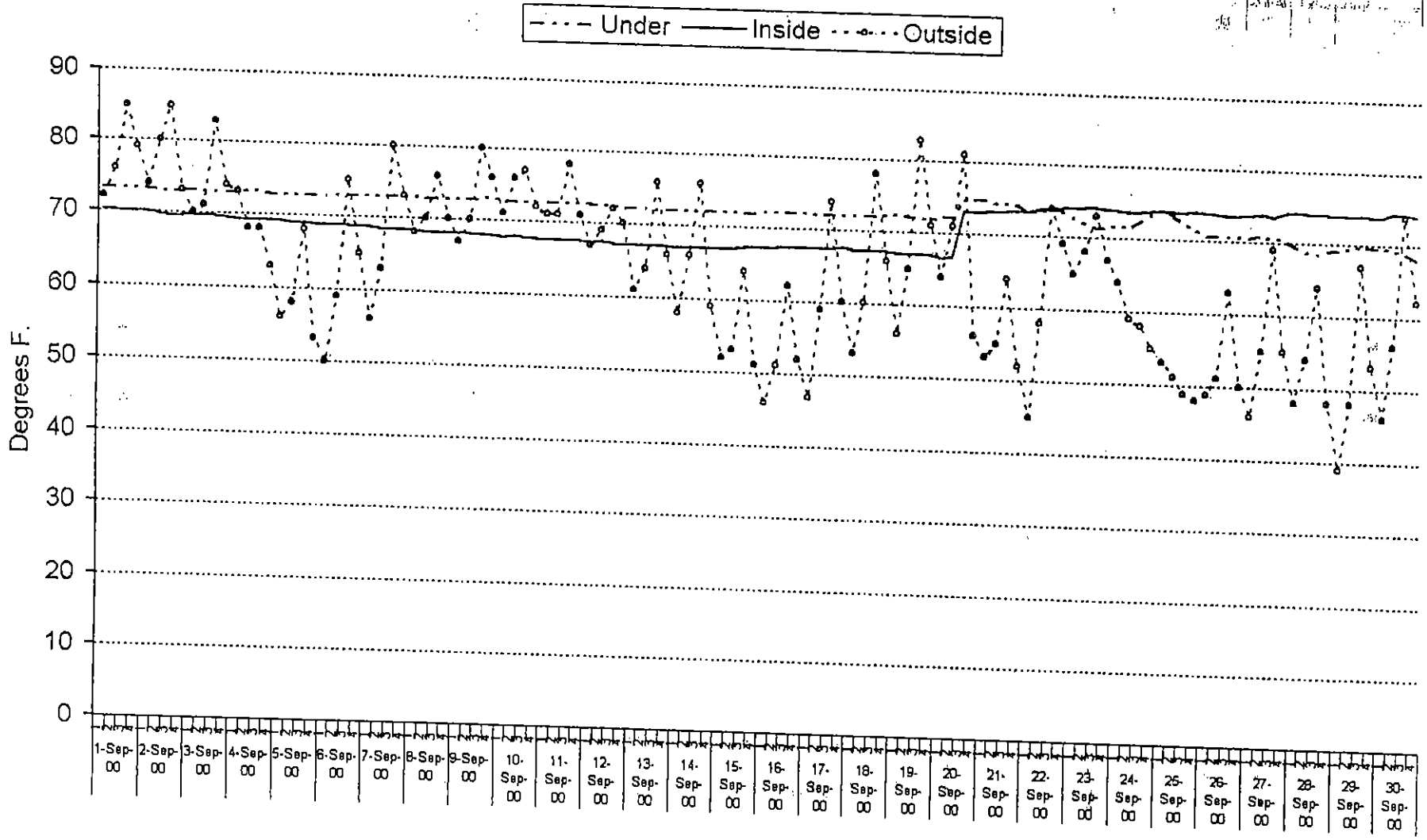
31-Aug-00

Temperatures September, 2000



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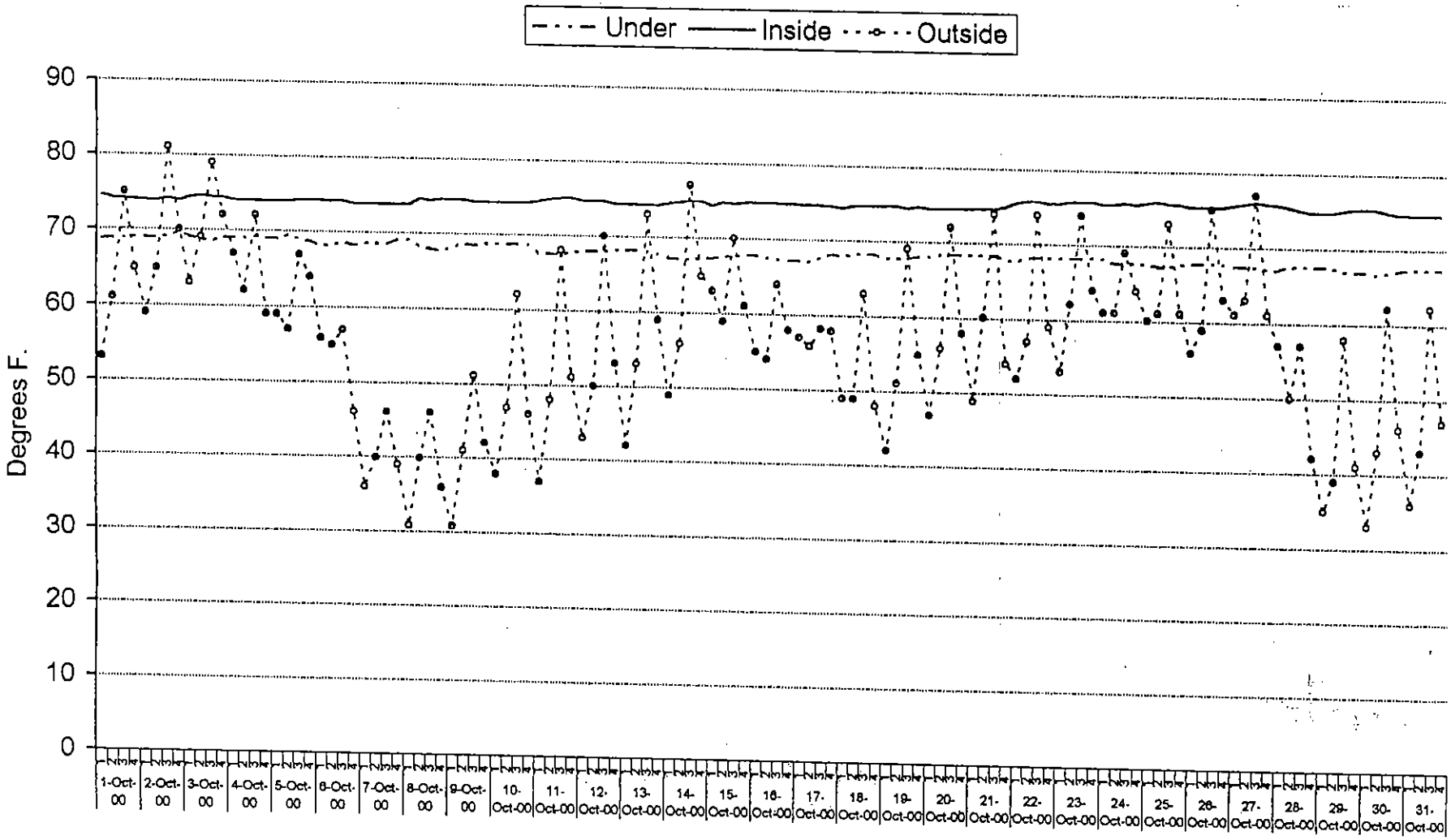

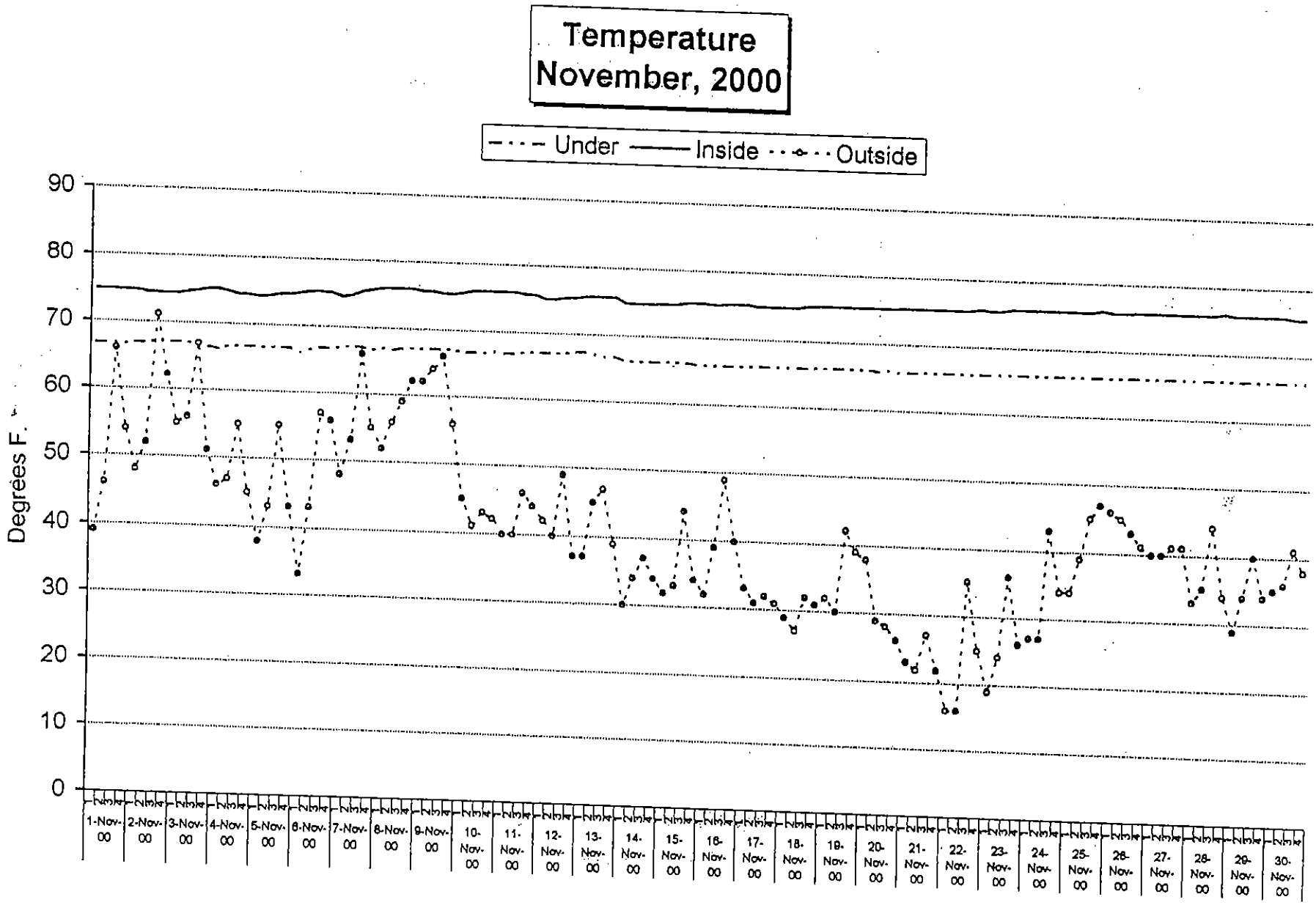
Temperature
November, 2000
Under
Inside
Outside
Degrees F.
90
80
70
60
50
40
30
20
10
0
1-Nov-00
2-Nov-00
3-Nov-00
4-Nov-00
5-Nov-00
6-Nov-00
7-Nov-00
8-Nov-00
9-Nov-00
10-Nov-00
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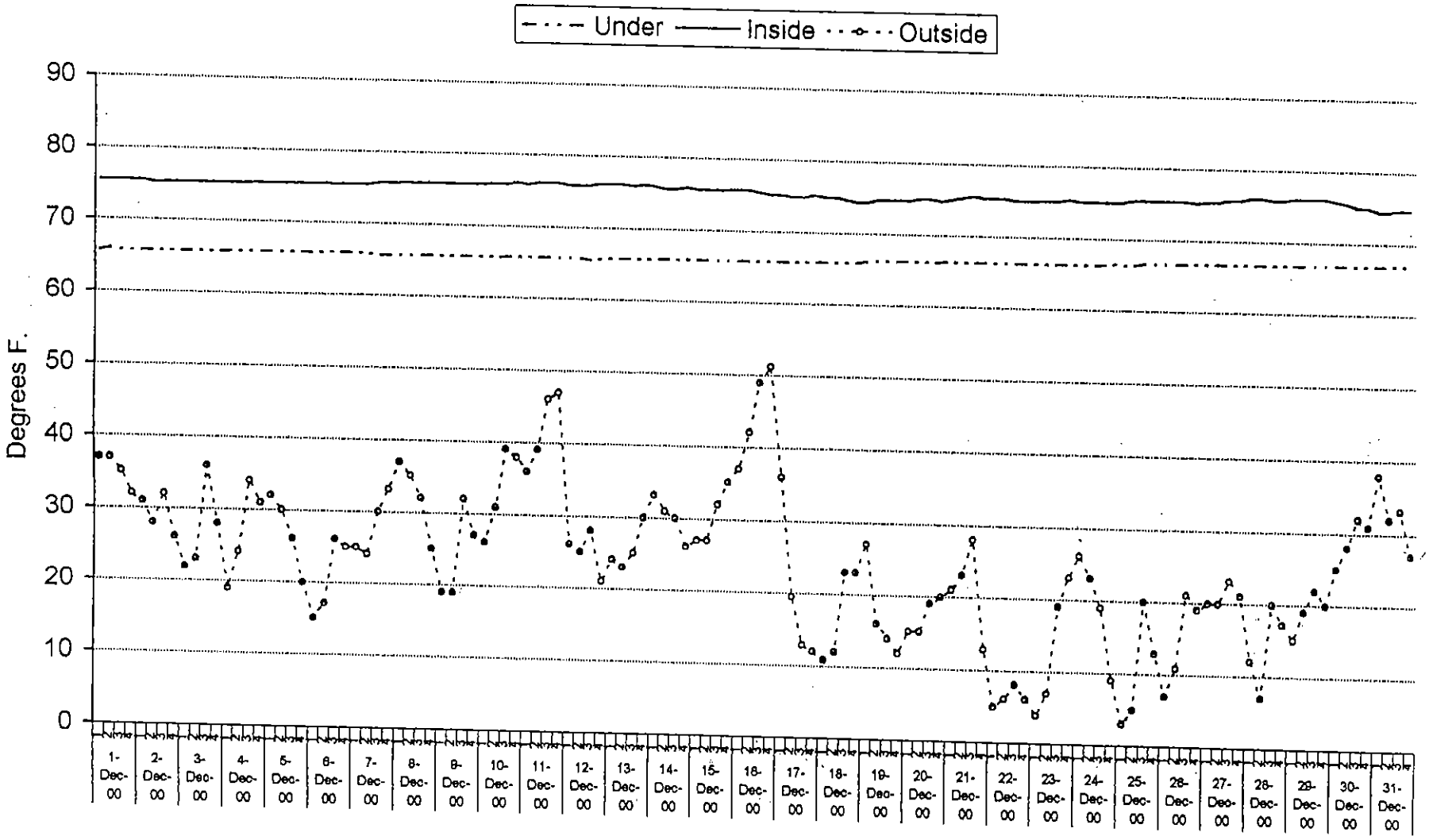
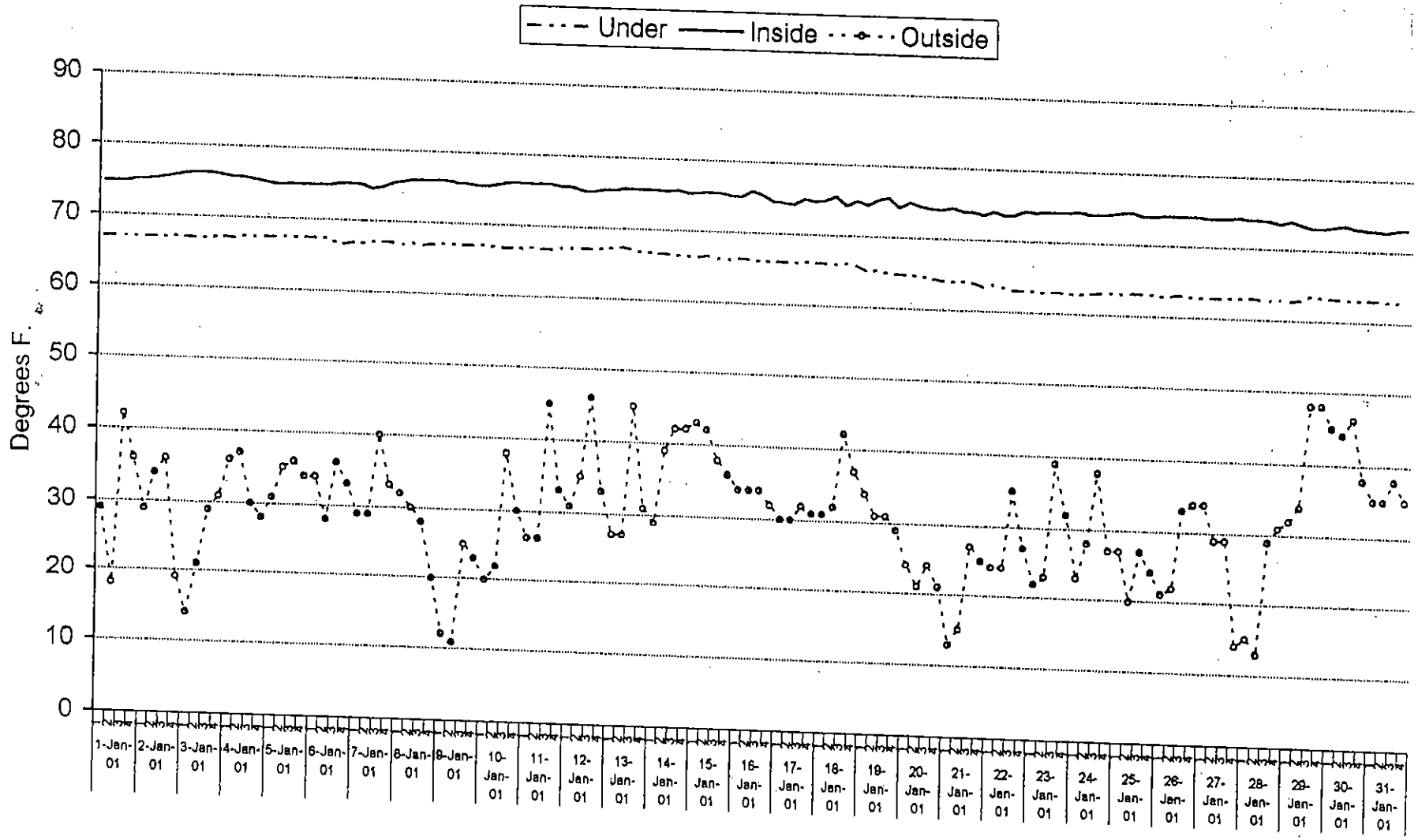
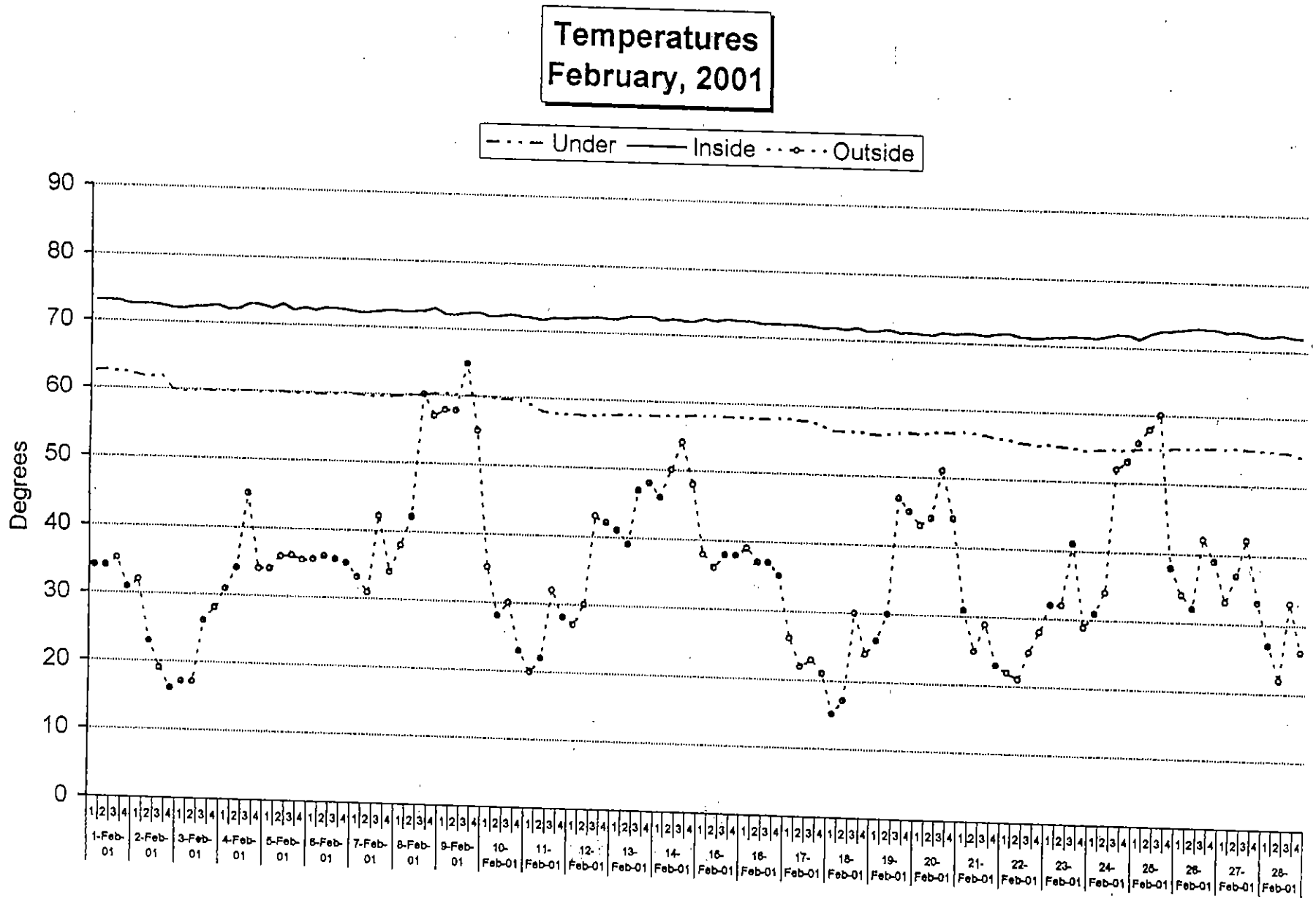
26-Nov-00
27-Nov-00
28-Nov-00
29-Nov-00
30-Nov-00

Temperatures December, 2000

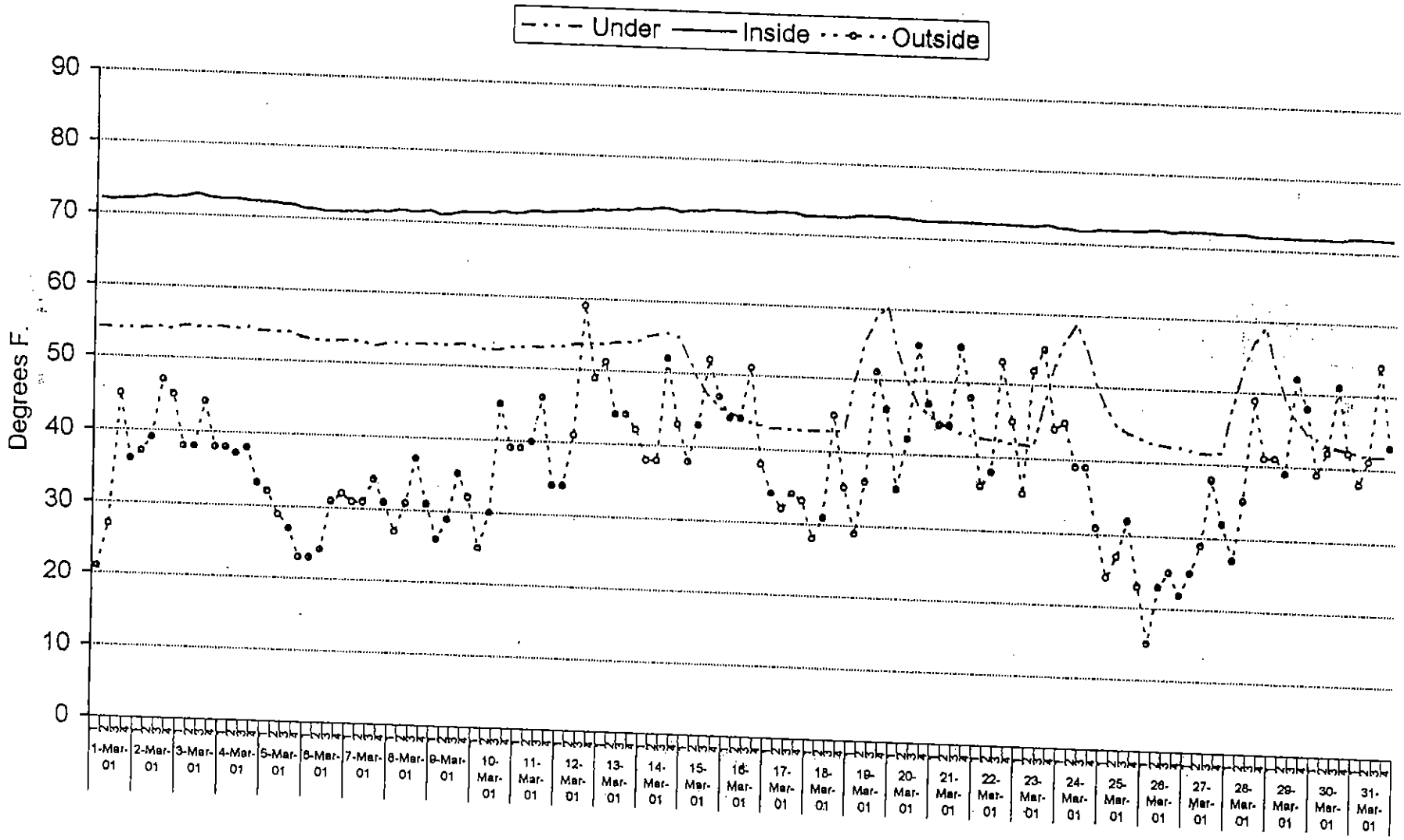


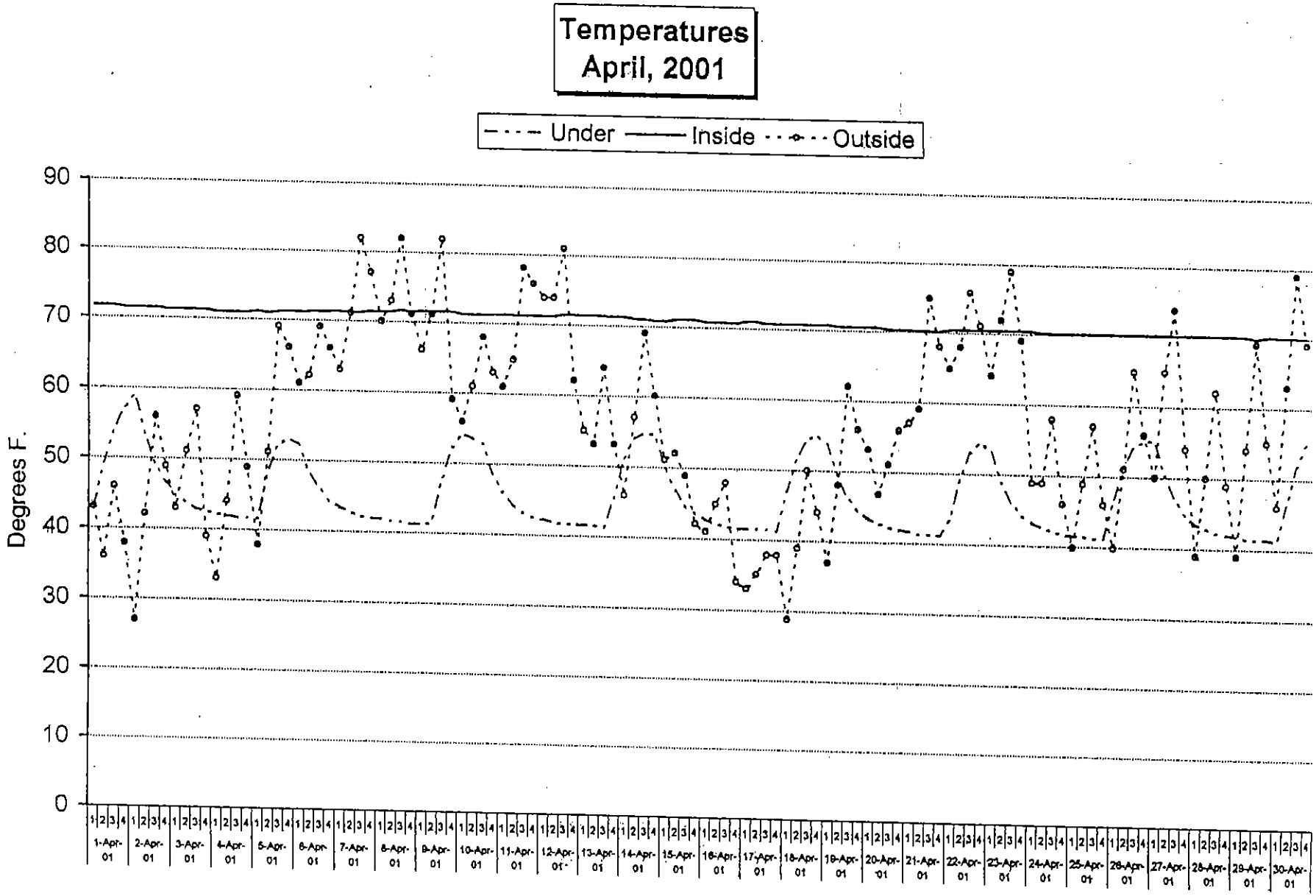
Temperatures January, 2001




Temperatures
February, 2001
Under
Inside
Outside
Degrees
90
80
70
60
50
40
30
20
10
0
1-Feb-01
2-Feb-01
3-Feb-01
4-Feb-01
5-Feb-01
6-Feb-01
7-Feb-01
8-Feb-01
9-Feb-01
10-Feb-01
11-Feb-01
12-Feb-01
13-Feb-01
14-Feb-01
15-Feb-01
16-Feb-01
17-Feb-01
18-Feb-01
19-Feb-01
20-Feb-01
21-Feb-01
22-Feb-01
23-Feb-01
24-Feb-01
25-Feb-01
26-Feb-01
27-Feb-01
28-Feb-01

Temperatures March, 2001




Temperatures
April, 2001
Under
Inside
Outside
Degrees F.
90
80
70
60
50
40
30
20
10
0
1-Apr-01
2-Apr-01
3-Apr-01
4-Apr-01
5-Apr-01
6-Apr-01
7-Apr-01
8-Apr-01
9-Apr-01
10-Apr-01
11-Apr-01
12-Apr-01
13-Apr-01
14-Apr-01
15-Apr-01
16-Apr-01
17-Apr-01
18-Apr-01
19-Apr-01
20-Apr-01
21-Apr-01
22-Apr-01
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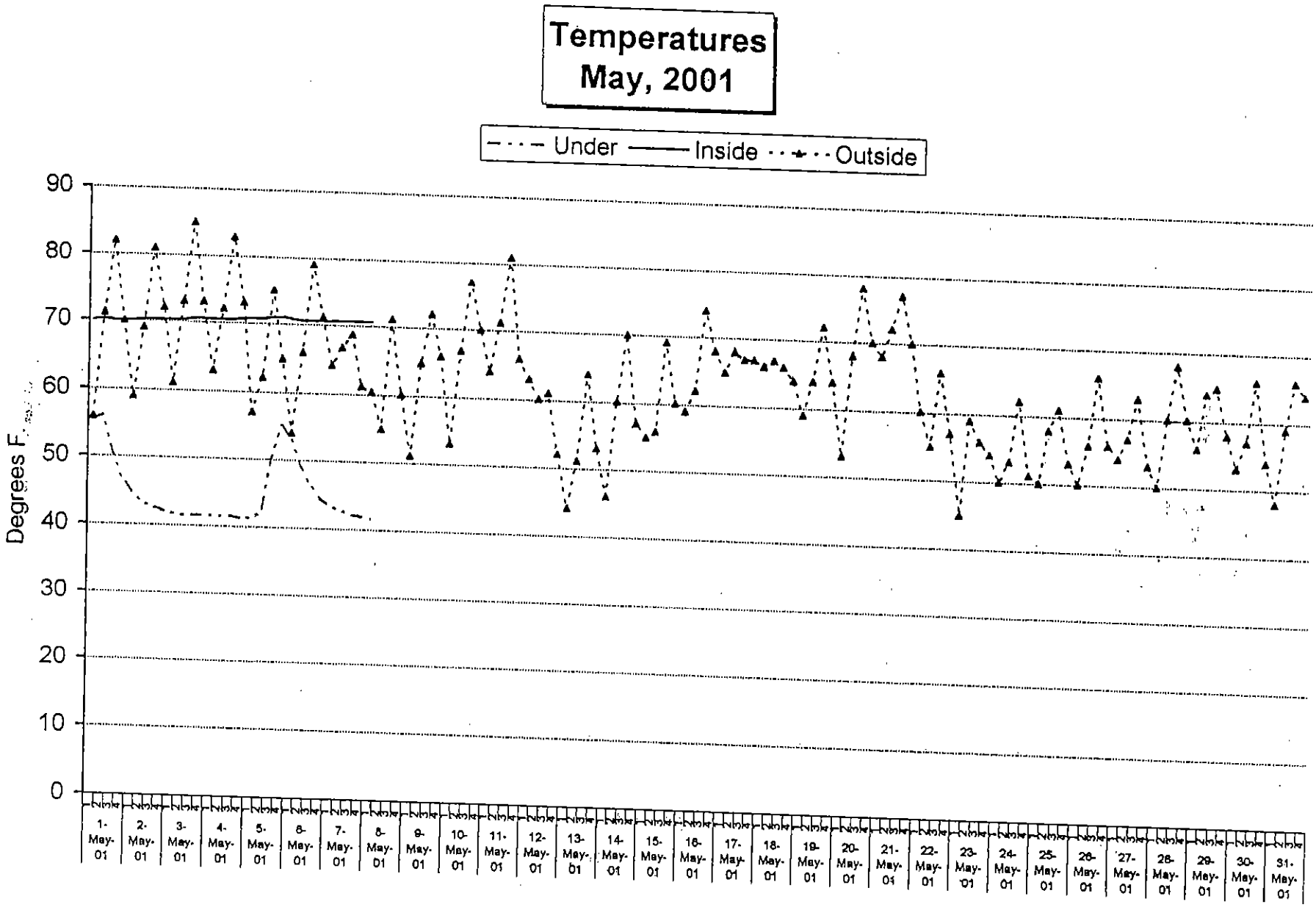
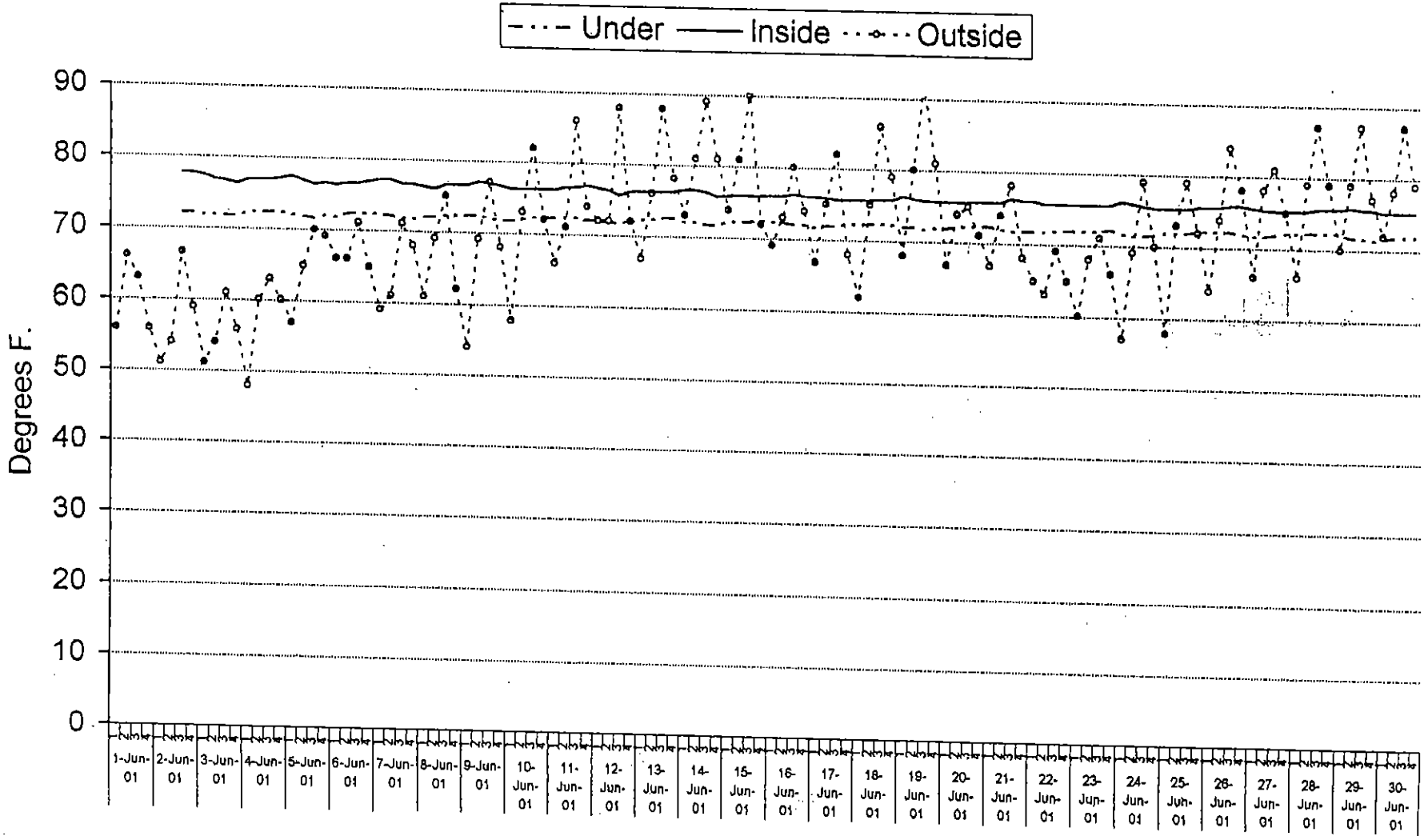
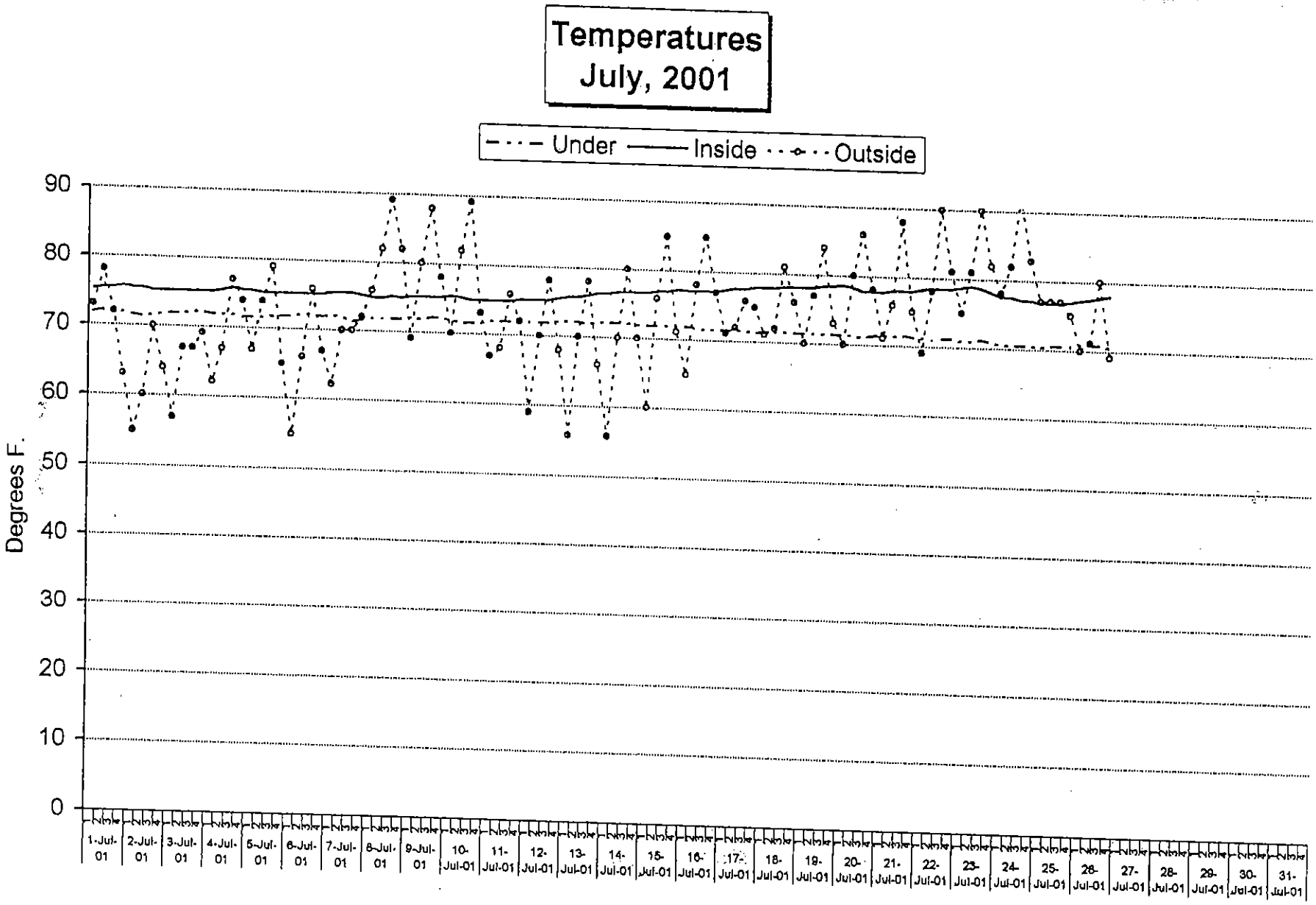
26-Apr-01
27-Apr-01
28-Apr-01
29-Apr-01
30-Apr-01


Temperatures
May, 2001
Under
Inside
Outside
Degrees F
90
80
70
60
50
40
30
20
10
0
1-May-01
2-May-01
3-May-01
4-May-01
5-May-01
6-May-01
7-May-01
8-May-01
9-May-01
10-May-01
11-May-01
12-May-01
13-May-01
14-May-01
15-May-01
16-May-01
17-May-01
18-May-01
19-May-01
20-May-01
21-May-01
22-May-01
23-May-01
24-May-01
25-May-01
26-May-01
27-May-01
28-May-01
29-May-01
30-May-01
31-May-01

Temperatures June, 2001




Temperatures
July, 2001
Under
Inside
Outside
Degrees F.
90
80
70
60
50
40
30
20
10
0
1-Jul-01
2-Jul-01
3-Jul-01
4-Jul-01
5-Jul-01
6-Jul-01
7-Jul-01
8-Jul-01
9-Jul-01
10-Jul-01
11-Jul-01
12-Jul-01
13-Jul-01
14-Jul-01
15-Jul-01
16-Jul-01
17-Jul-01
18-Jul-01
19-Jul-01
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21-Jul-01
22-Jul-01
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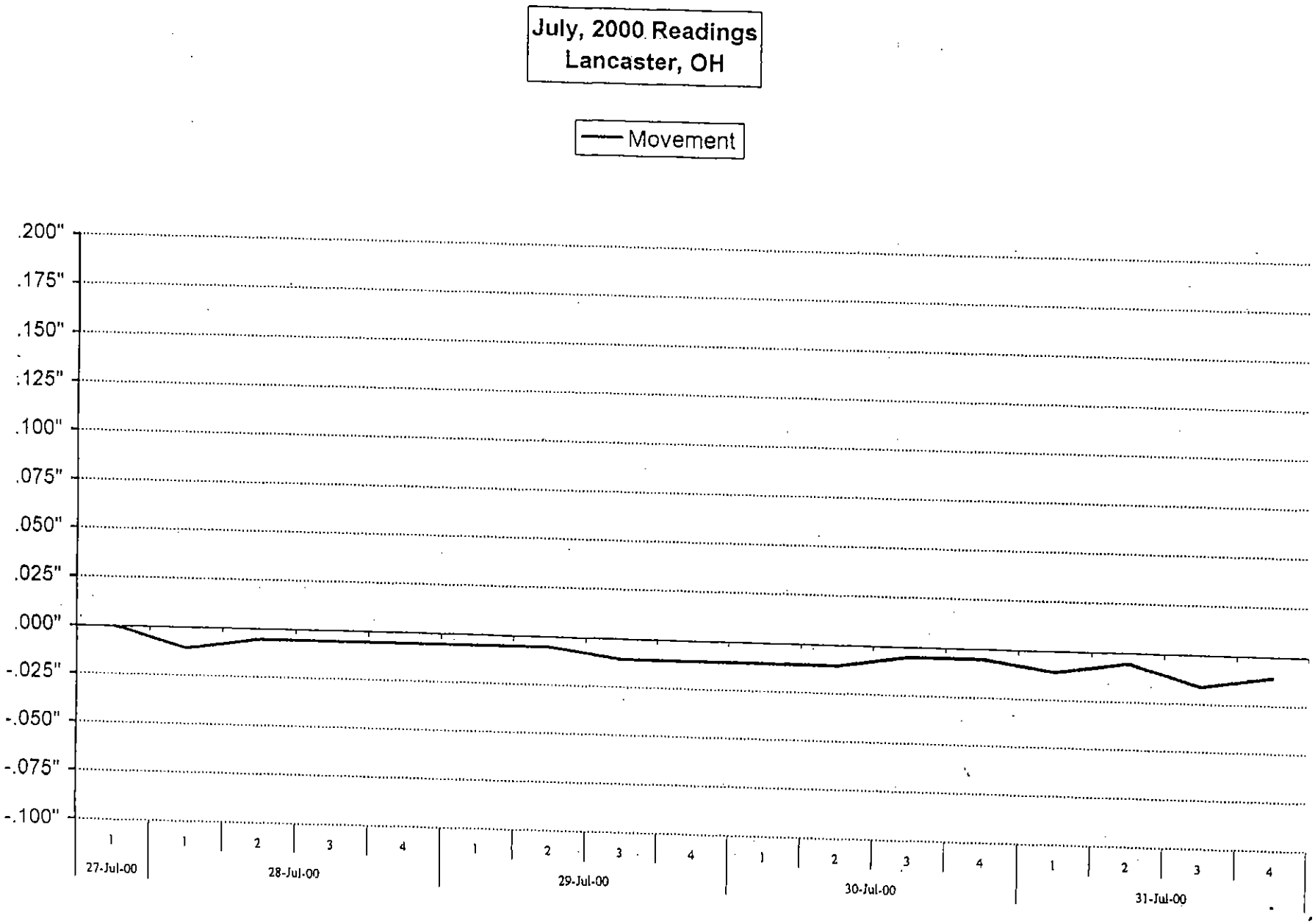
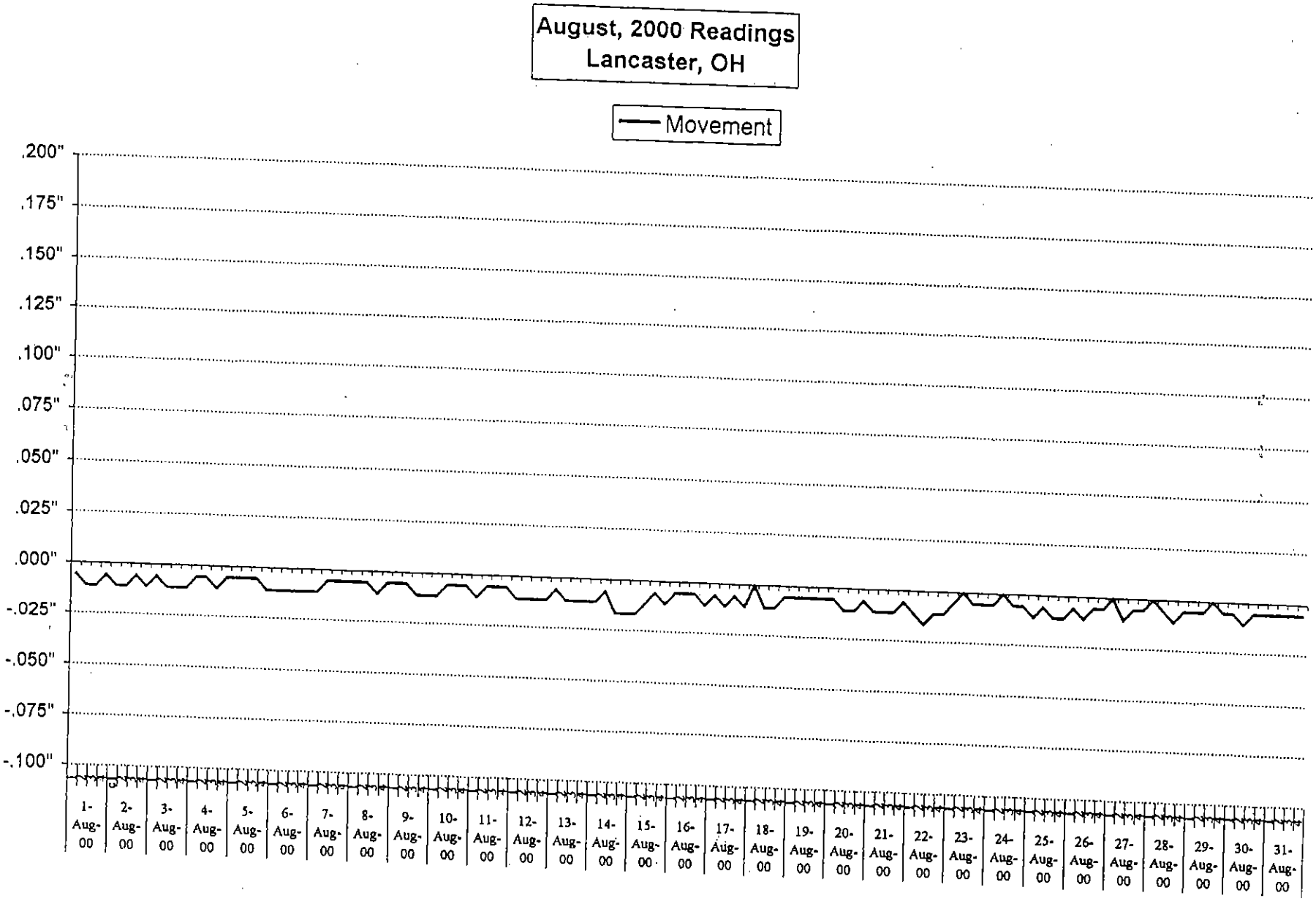
30-Jul-01
31-Jul-01


July, 2000 Readings
Lancaster, OH
Movement
.200"
.175"
.150"
.125"
.100"
.075"
.050"
.025"
.000"
-.025"
-.050"
-.075"
-.100"
1
27-Jul-00
1
2
3
4
28-Jul-00
1
2
3
4
29-Jul-00
1
2
3
4
30-Jul-00
1
2
3
4
31-Jul-00


August, 2000 Readings
Lancaster, OH
Movement
.200"
.175"
.150"
.125"
.100"
.075"
.050"
.025"
.000"
-.025"
-.050"
-.075"
-.100"
1-Aug-00
2-Aug-00
3-Aug-00
4-Aug-00
5-Aug-00
6-Aug-00
7-Aug-00
8-Aug-00
9-Aug-00
10-Aug-00
11-Aug-00
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14-Aug-00
15-Aug-00
16-Aug-00
17-Aug-00
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20-Aug-00
21-Aug-00
22-Aug-00
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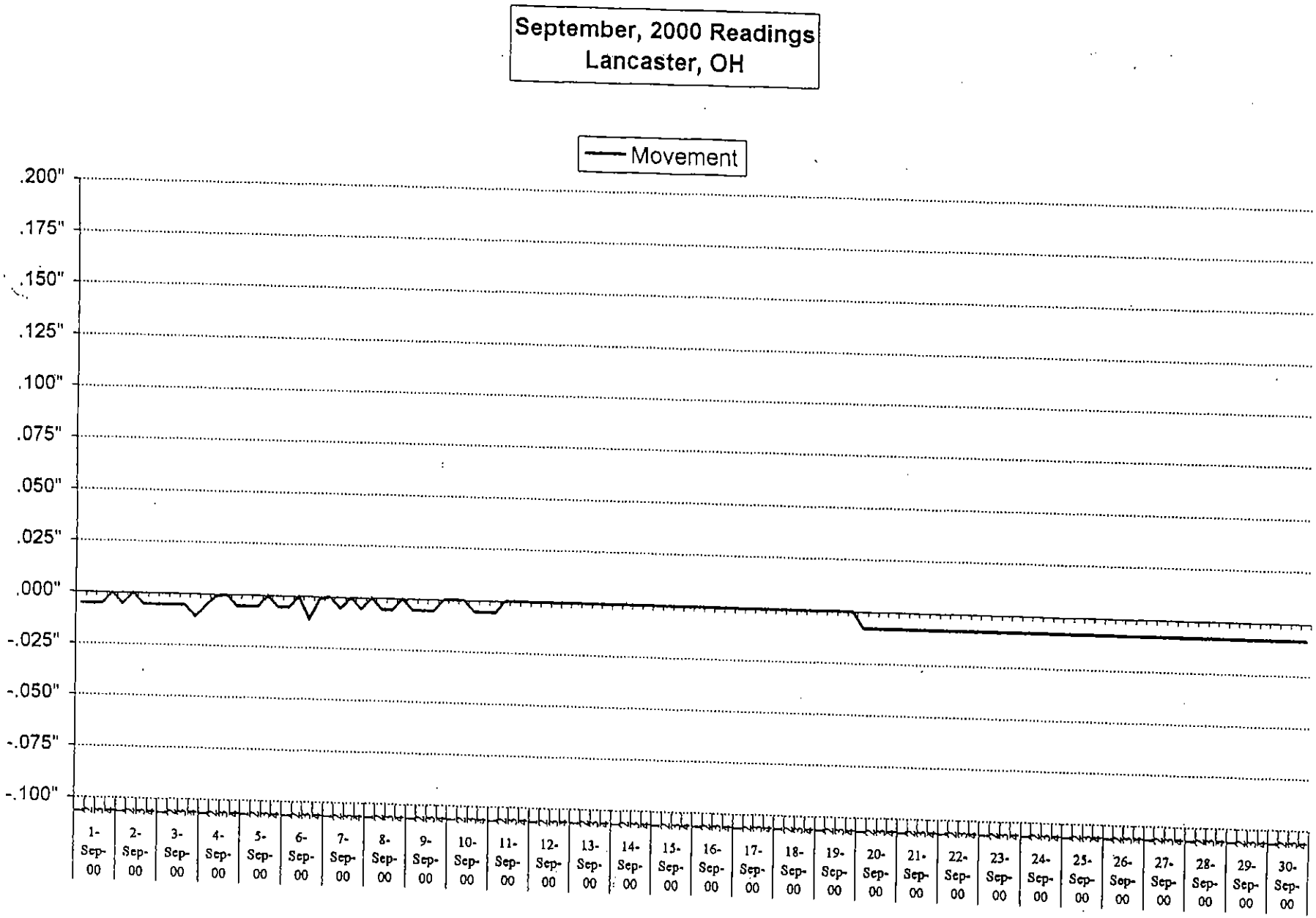
30-Aug-00
31-Aug-00


September, 2000 Readings
Lancaster, OH
Movement
.200"
.175"
.150"
.125"
.100"
.075"
.050"
.025"
.000"
-.025"
-.050"
-.075"
-.100"
1-Sep-00
2-Sep-00
3-Sep-00
4-Sep-00
5-Sep-00
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29-Sep-00
30-Sep-00