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ENERGY CONSERVATION AT THE PURNELL SCHOOL

by

William J. Jones and James W. Meyer

Energy Laboratory Working Paper
Number MIT-EL 77-004WP
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Staff of the Energy Laboratory of MIT, under a grant from Mrs. Dora M. Lewis of Ohio, conducted studies of energy conservation and solar energy application at typical residential secondary schools. The study was performed and reports written so that the results could be used to assist in energy conservation and possible solar energy application at similar facilities across the country.

Three schools were considered: (a) the St. Mark's School in Southborough, Ma., where an in-depth study was made, (b) St. George's School in Newport, Rhode Island, and the Purnell School, Pottersville, New Jersey were sites of brief surveys to include different fuels and consumption mixes in our investigations.

This particular report contains comments on energy conservation opportunities at the Purnell School. We have included, as appendices, certain portions of the reports on energy conservation at the others. The reader is encouraged, if a serious effort is made to implement energy conservation at a facility, to refer to the Massachusetts Institute of Technology Energy Laboratory publications, "Solar Energy and Conservation at St. Mark's School, MIT-EL 77-001 and Working Paper "Energy Conservation at St. George's School, MIT-EL 77-003WP.

The Purnell School, Pottersville, New Jersey is a private residential secondary school with a population of about 95 girls. The main buildings are converted dairy farm facilities. The dormitories and dining hall were built for the purpose now used. In addition, there are a number of school owned faculty and staff residences. The school is primarily (there are some oil-fired systems) an electric-heated facility.

The St. Mark's School, which was chosen for detailed analysis because of its proximity to Cambridge, Massachusetts, has a power plant on campus capable of producing all of its electrical, steam, and hot water requirements.

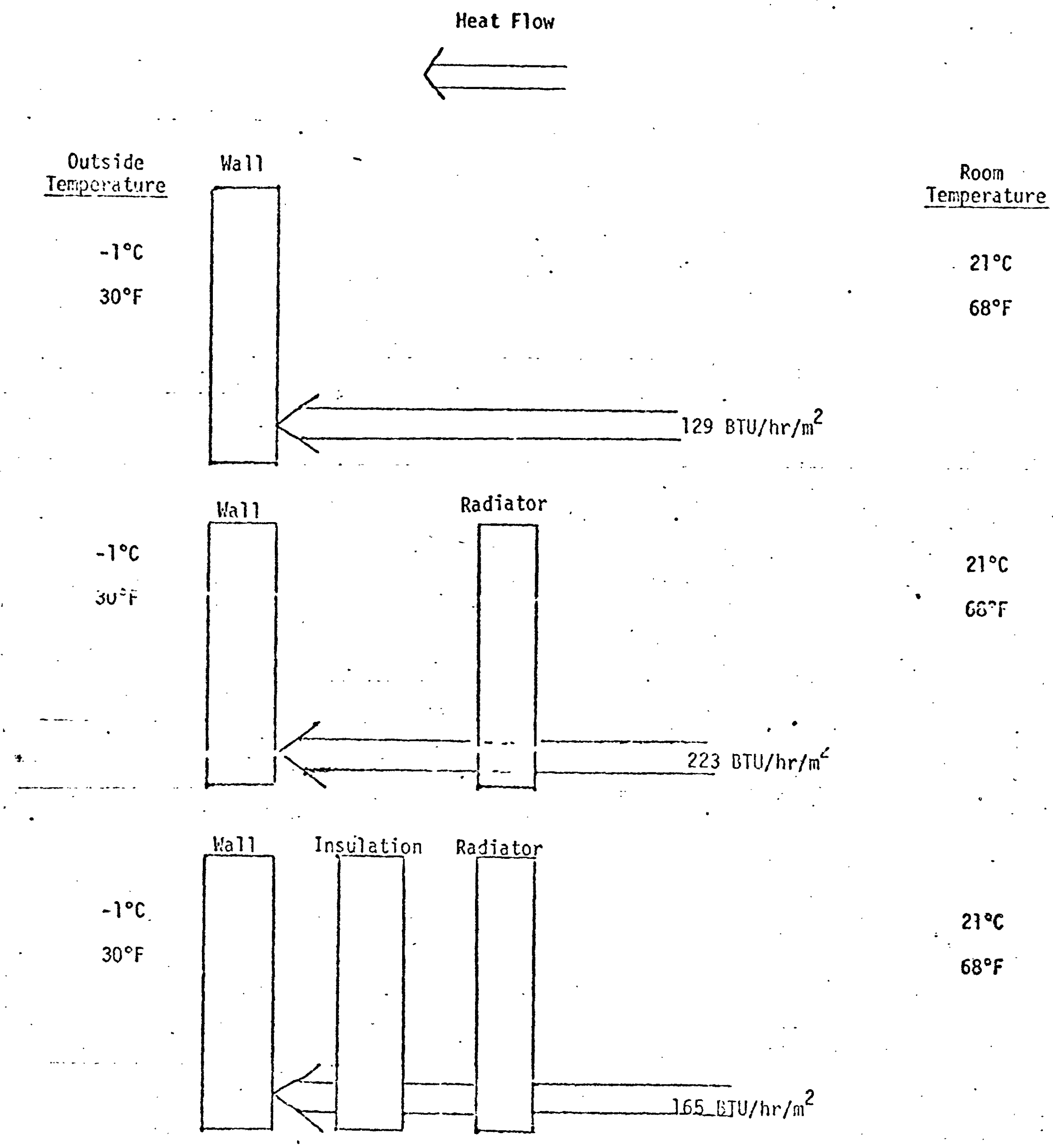
The St. George's School employs oil-fired furnace/boilers for hot water and steam and purchases its electricity from a public utility.

Mrs. D. Lewis was present during some of the days at St. Mark's and accompanied the authors to the Purnell School and the St. George's School.

During our visit to Purnell we spoke with Mr. Ward L. Johnson, Jr., the Asst. Headmaster and Business Manager, and the school plant superintendent. The following are our conclusions and recommendations:

1. For those buildings which are heated by oil-fired furnaces, discuss with the fuel supplier the possibility of reducing burner nozzle size. The oil consumption (firing rate) is generally set for the six coldest days of the year and this results in higher than required consumption. We include, as appendix to this paper, that portion of the report on the oil burners at the St. Mark's School that are pertinent to Purnell.

2. Insulation should be placed between radiators, (steam, electric hot-water), and the outside walls. Figure 1. illustrates how heat loss can be reduced.



1 sq. meter = 10.76 sq. ft.

Figure 1

Heat Loss Behind Radiators

3. There are several utility owned kilowatt hour meters monitoring the electricity consumption. The cost, as presently calculated by the utility, is arrived at by reading each individual meter and using the applicable rate for that quantity for the charges for each meter. The school's bill is then the sum of the meter charges rather than a cost based on a rate that could be for the total electricity consumed by the school.

If the entire school's electrical energy consumption were used to determine the applicable New Jersey DPU rate, the total monthly cost should be considerably less.

The most proper thing to do would be to install one meter and feed all circuits from it. That would require capital investment. It is suggested that the first step would be to try to convince the utility that since all elelctricity is consumed within the school property, the energy readings of the several meters should be summed and then the applicable rate, based on total consumption, applied.

4. Electric hot water heating should be accomplished at "off-peak" hours as much as possible. This should cost less. Discussions with the utility are recommended.

5. In all the buildings there are steam and hot water pipes which should be better insulated. Hallways and stairwells need not be at the same temperature as rooms. We suspect that in some passageways the temperature, due to less than enough insulation on distribution pipes, is higher than in living areas.

6. There was evidence that the clean-out doors on some of the furnaces are not sealed properly. The oil burner service technician should be consulted.

7. Oil burner efficiency measurements and tune-up records should be obtained from the dealer and maintained at the school. Reasoning for this is contained in Appendix I.

8. The doors of many of the buildings should be repaired or modified so that tightness is insured. The entrance doors to the Arthur Gardner Building are a classic example.

9. The above ground portions of basements of many of the buildings are high enough to permit use of the basements as classrooms, common rooms, etc. Therefore they are heated to occupancy level temperatures. We were able to detect temperature differences up and down the foundation walls with our hands, physical evidence of heat losses through the concrete walls.

We did not conduct an infra-red scan (thermography) test at the school because of distance; the equipment was located in Massachusetts.

We refer readers to the St. Mark's report for examples of heat loss through walls and windows.

In this report we include photographs taken by scientists of the Cold Regions Laboratory of the Corps. of Engineers at Hanover, New Hampshire. They are applicable to Purnell because of the extensive use of semi-basement areas for school activities. The foundation walls are not insulated either on the earth/air outsides or on the insides.

In Figure 2 (a) one can see a concrete wall in which two windows and a door are located. The regular door is protected with an aluminum storm door. The windows, too, have storm sashes. The bottom portion of the storm sash on the one to the left of the door has been raised.

We must remember that in these reproductions of the IR scan, as in other referenced reports, hot surfaces are represented as white, warm ones grey and cool surfaces in black.

Figure 2 (b) (the infra-red picture) it is quite apparent that the storm door does help. The upper portion of adjacent left-hand window in almost black, the result of two storm window panes. The lower portion of the window, where there is no storm sash, is white, indicating a large heat loss. Figure 3 is another illustration of heat loss through an uninsulated concrete foundation.

The almost dramatic part of the picture, though, is the white foundation. There is no insulation on the inside and, as a result, there is considerable heat loss through the concrete foundation. We noticed no insulation on any of the insides of foundations of Purnell School buildings that we inspected. Insulation should be applied to the inside of foundations the extent they are above ground and below ground to at least 3 feet below the frost level, see Figure 4. We also refer the reader to the bibliography of the St. Mark's report, particularly "In the Bank or Up the Chimney" as to how to install the insulation. An excerpt is contained in Appendix II.

10. There is a possiblility there is no perimeter insulation in the foundation of the Cristin House. This should be verified by the

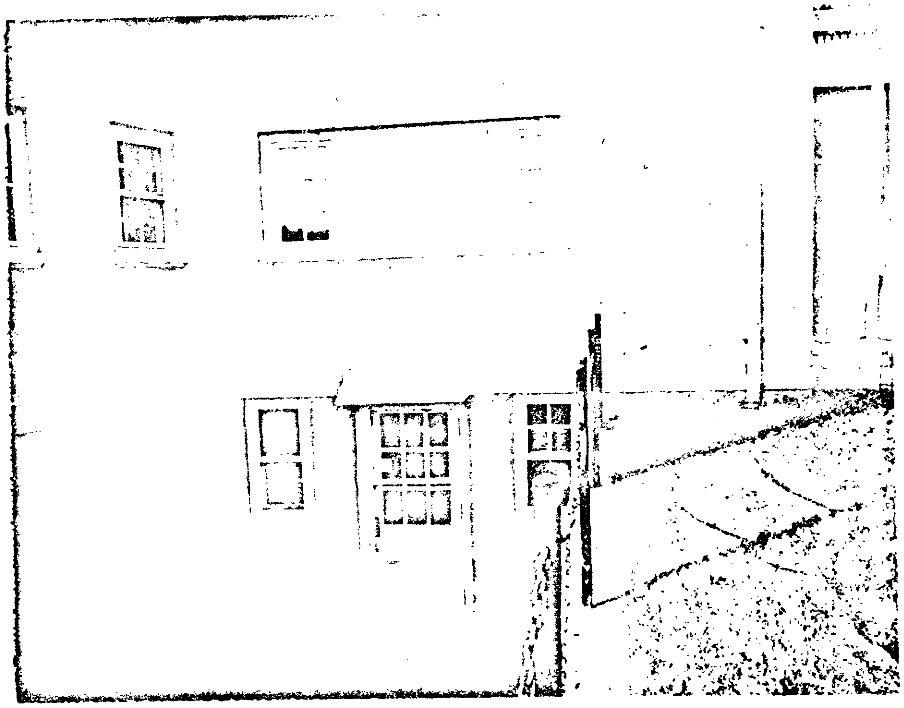


Figure 2a

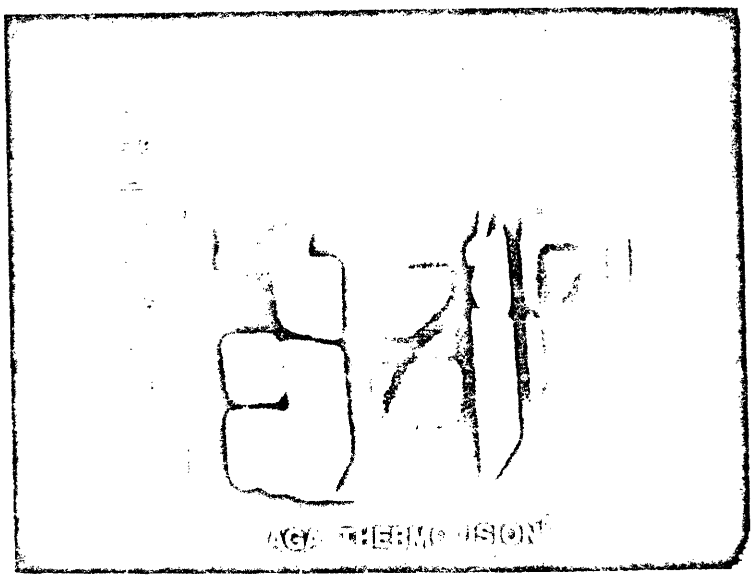


Figure 2b

Figure 2

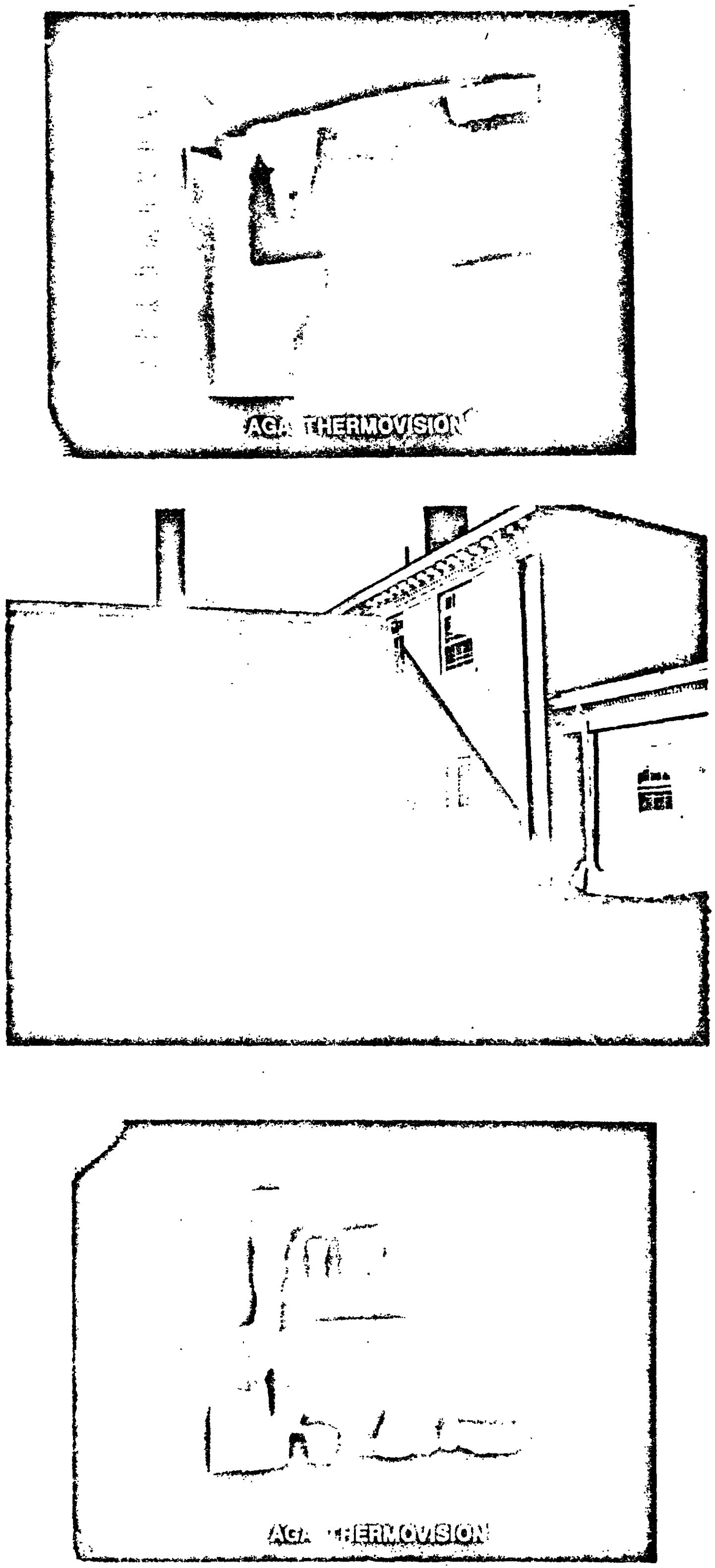
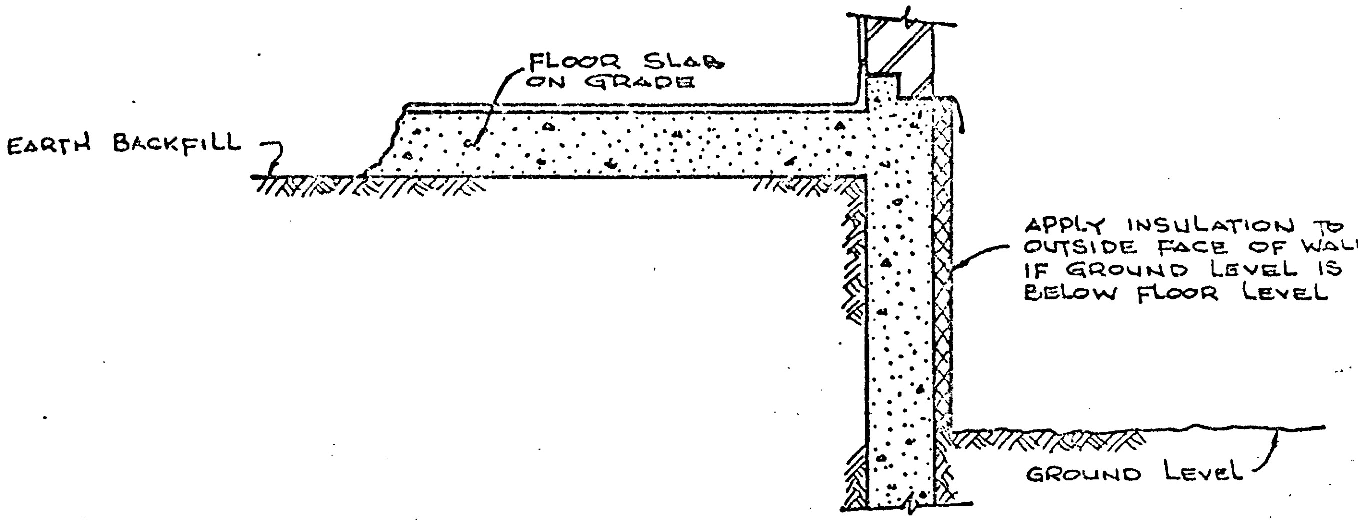


Figure 3



Insulation materials may be rigid board or foam as described for walls. Insulation below ground should be applied in a bedding of hot asphalt. Existing flashing at ground floor level may require extending to cover the insulation top edge.

The savings due to edge insulation cannot be predicted with any accuracy. If, however, condensation occurs on the floor perimeter in cold weather or if the floor surface temperature close to the outside wall is more than 10° F, lower than the indoor temperature, then insulation will be beneficial and should be added.

Suspended floors over an unheated space (garage, crawlway, etc.) may be insulated on the underside by applying spray foam or rigid insulation as described for roofs.

Figure 4

architect. One possible correction is shown in Figure 4.

11. Storm-windows are recommended for all fixed sash in the library. They may be glass or plastic in the standard extruded aluminum frames or rigid plastic sheets cut to fit within the frames of the inside of the window.

12. There appeared to be an excess of illumination fixtures. In the library alone it is estimated that over five and one-half kilowatts of overhead fixtures plus quite a number of floor and desk lamps, are used to illuminate a 35' x 60' floor area.

Attached, Appendix III contains data that can be used to arrive at optimum lighting and energy consumption.

13. The electrically heated hot water tanks in the dormitories, kitchen and elsewhere in the school, are purchased with a given amount of insulation covered by a metal (outside) shell. Tests performed elsewhere indicate that additional insulation would be cost-effective. Staff can purchase ordinary four inch wool batten insulation with aluminum vapor barrier and wrap it around the tanks. Sections, cut to size and shape, can be fitted onto the top and underneath. The aluminum vapor barrier should be on the outside.

14. Flow restrictors, Appendix IV should be installed in all showers and basin water faucets.

15. Time clocks, in combination with thermostats with set points for "occupied" "unoccupied" conditions should be installed so as to control space heating in areas which house activities for only a portion of each 24 hour period and not at all on week-ends.

G. FUEL CONSERVATION IN DOMESTIC OIL BURNERS

1. Rationale for Oil Burner Study

Laboratory and field tests of domestic oil burners have shown that substantial savings in fuel oil can be made at minimal cost. Savings of up to 30% have been realized by carefully adjusting, cleaning, and sealing the furnace system, often called a "tune-up". Actual savings depend on how badly out of tune a particular furnace becomes between servicings. In general, older furnace systems degrade faster than later models but this is not always the case.

Current practice in oil burner maintenance calls for annual inspection and tune-up. Most often this is done in the summer, an "off-peak" season for furnace servicemen. It has become important to determine whether annual servicing is adequate for a given installtion. At current oil prices, more frequent tune-ups may be quite cost effective.

Three elements of the total efficiency of oil heating units are combustion efficiency, heat transfer efficiency, and duty cycle or down-time losses.

The efficiency of the combustion process in all but the most exceptional cases can exceed 99%.

The efficiency of heat transfer, the process of getting the heat of the combustion into the medium (air, water, or steam) used to heat the house, depends upon the configuration of the furnace system and the condition of the heat transfer surfaces. This efficiency, for a number of reasons, cannot exceed 80% and can vary from 50% to 80%. Excessive soot on the heat transfer surfaces is a major contributor to inefficient heat transfer because soot is a relatively good themal insulator -- a clean furnace is more efficient. See Figure 12.

Duty cycle or down-time losses have to do with the way our heating units are operated to meet the varying demands for heat in the house -- basically an "on-off" cycle. To supply heat at capacity, the unit is operated continuously. The burner very rarely operates continuously. Most burners are cycled frequently with a moderate time "on" and a longer time "off". The "on" time is an especially small fraction of the "off" time during the moderate weather of spring and fall. Smoke and soot are greater at the beginning of the "on" cycle before the heating unit reaches stable equilibrium conditions.

Duty cycle losses occur because when the burner is turned "off", having met the demand for heat, hot air continues to pass out of the chimney as the unit cools. Heated air from the house is lost in the process and is replaced by cold air which infiltrates from the outside. The lower the duty cycle (the fraction of the total time the burner is "on"), the greater are these losses. Automatic dampers which close the flue when the burner is off can eliminate these losses. Some equipment of European manufacture is equipped with devices to eliminate duty cycle losses. None is made for domestic use in the United States. Duty cycle losses averaged over a heating season are typically 15%. There are safety considerations to take into account if an automatic damper is used.

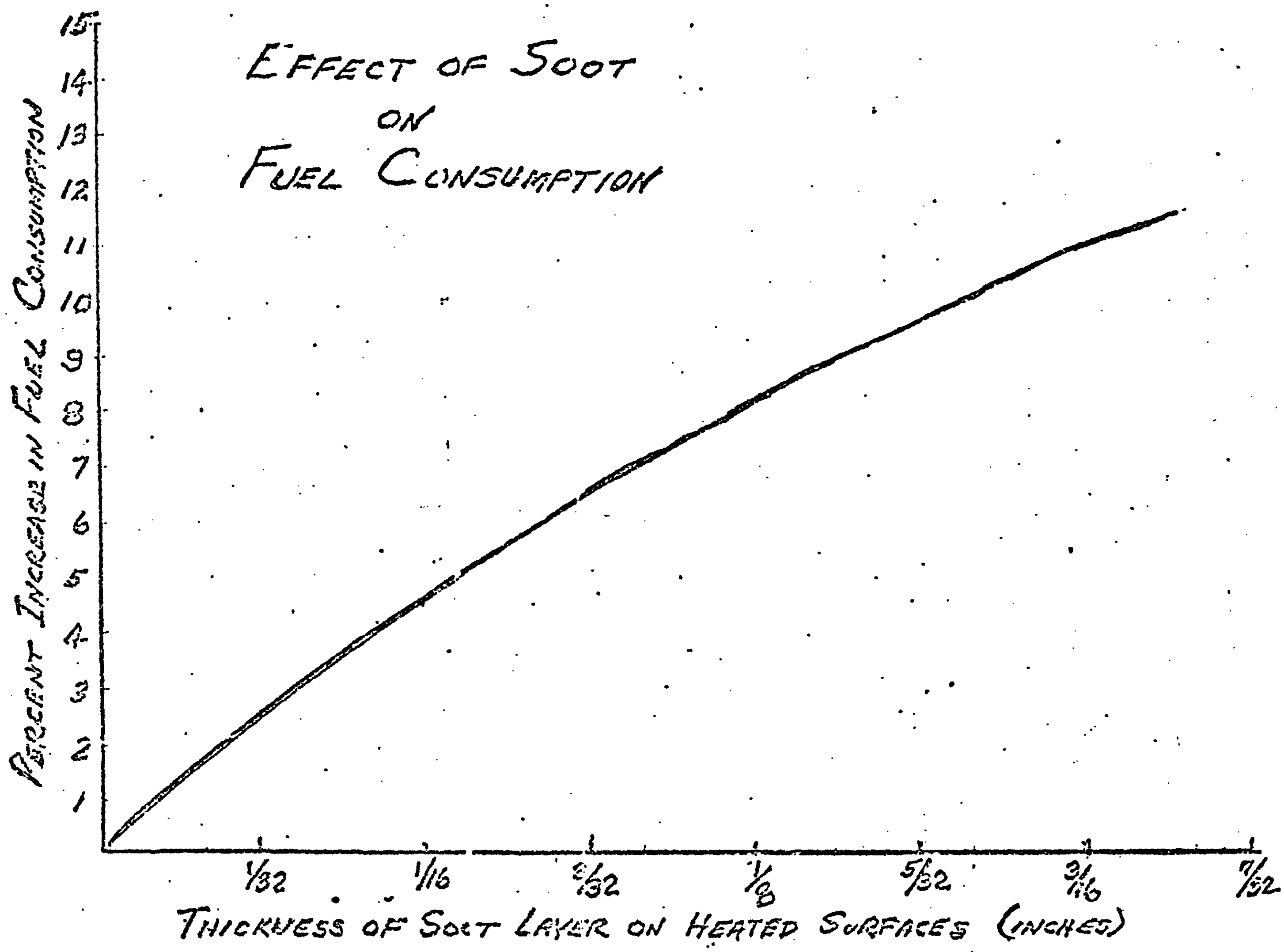


Figure 12

Effect of Soot

It is possible to reduce duty cycle losses by reducing the firing rate (burning) of the burner. At a reduced firing rate the burner is "on" longer to produce a given amount of heat. Because of the substantial safety factors allowed in the sizing of most residential heating units, the firing rate can be reduced by about 25% in most cases without affecting comfort. We can see from Figure 13 that a typical situation shows that 90% of the time heat load is 60% or less. Even further reductions are possible in those houses where thermostats have been turned down. The burner firing rate can be reduced simply by replacing the nozzle with one of smaller capacity. Nozzles are usually replaced annually so the reduction in firing rate would not involve extra cost. Figure 14 illustrates the penalty paid in efficiency for over-design and system operation at only a fraction of full load. The figure shows that if the plant is 100% overdesigned we operate the furnace at only half capacity for full load and only 30% capacity 90% of the time. This further reduces boiler efficiency by 15% to 20%.

This quest for improved efficiency pays greater dividends than might appear to casual consideration. Small improvements in inefficient units pay larger dividends in fuel saved. For example, a 50% efficient furnace requires 10 gallons of oil to produce five gallons equivalent of heat. Five gallons equivalent are lost. If performance is improved to 55%, about nine gallons of oil are required to produce five gallons equivalent of heat, a 10% savings in fuel for a 5% improvement in efficiency! It is therefore important to attend to the least efficient systems first.

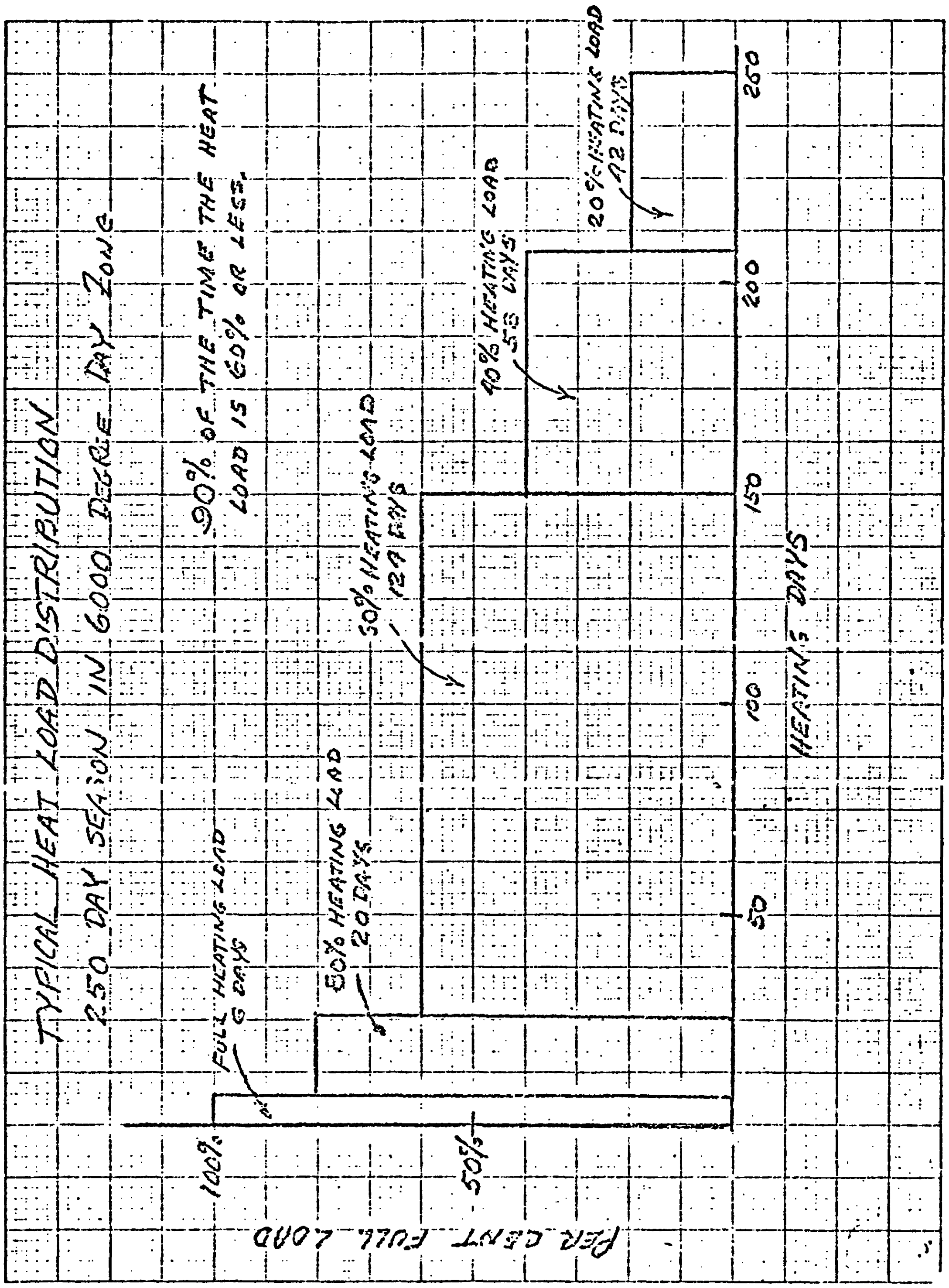


Figure 13

Typical Heat Load Distribution

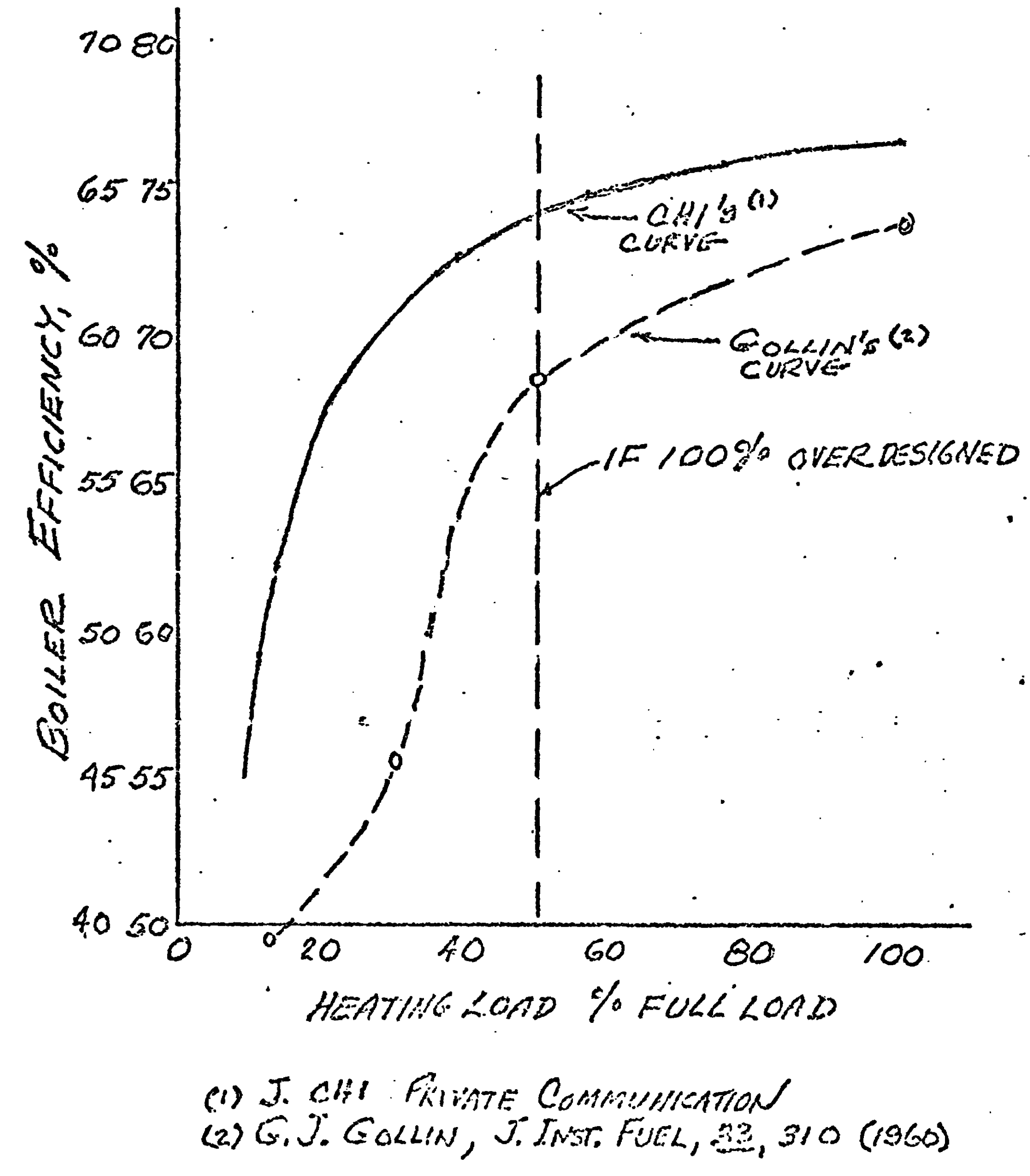


Figure 14

Boiler Efficiency as a Function of Heating Load

The table in Figure 15 shows the fuel saved for various initial and final efficiencies achieved.

2. A Study of Oil Burner Performance in Selected Masters' Dwellings (St. Mark's School)

a. General Comments

As a result of our survey and comparison with other field oil burner studies, we conclude that oil consumption in the Masters' Dwellings is, with a few exceptions, excessive. There can be many reasons for this, but we have mainly limited our considerations to the technical. Because incentives are so important to the realization of conservation goals, the others are worth considering.

b. Incentives for Reduction (Institutional)

St. Mark's now meets all the demand for fuel oil in the dwellings. Since oil is a non-substitutable "free good" under these conditions, there is no economic incentive for the residents to practice energy saving -- only that of conscience and a recognition of the national need to conserve our dwindling resources. We all need more than that.

We fully recognize the problems involved in setting up a fair and equitable allotment system of fuel oil. Yet we belive an allotment system to be in the best long-range interest of St. Mark's and its staff. The savings that would surely result from such a system could be very useful in meeting other critical and continually rising operating costs of the school.

ORIGINAL EFFICIENCY (η_0) \ EFFICIENCY AFTER TUNEUP (η_A)	55%	60%	65%	70%	75%	80%	85%	% Efficiency Improvement ($\eta_A - \eta_0$)
50%	9.1%	16.7%	23.1%	28.6%	33.3%	37.5%	41.2%	35%
55%		8.3%	15.4%	21.5%	26.7%	31.2%	35.3%	30%
60%			7.7%	14.3%	20.0%	25.0%	29.4%	25%
65%				7.1%	13.3%	18.8%	23.5%	20%
70%					6.7%	12.5%	17.6%	15%
75%						6.3%	11.8%	10%
80%							5.9%	5%

$$\% \text{ SAVINGS} = \frac{\eta_A - \eta_0}{\eta_A} \times 100$$

Figure 15

Percent Fuel Savings for Increased Efficiency

We understand that the questionnaire circulated under Project Conserve, Appendix VII, was completed for each of the Masters' Dwellings. The data contained in these questionnaires and the results of the analyses can help establish equitable allotments for each dwelling. One season's experience with new firing rates and new preventive maintenance techniques will provide additional needed data. With this basic information, trial allocations of fuel oil can be made. There should be no penalty to the householder for factors beyond his or her control, but he or she should be required to pay for that extra consumption that was a voluntary decision on his or her part. To add a carrot aspect to this stick, savings resulting from this approach must be specifically identified and put to a use recognized by the whole community, e.g., library books, etc.

c. Opportunities for Savings

Because combustion chambers in heating units are designed to accommodate the firing rate for the rated capacity, there can be a small loss of heat transfer efficiency (typically 2%-4%) at the reduced firing rate, but this is far overshadowed by the reduction in duty cycle losses. The lower firing rate will reduce sooting so that, over the season, actual heat transfer losses due to a lower firing rate will be minimal. A practical minimum nozzle size may be over 1 gallon per hour to provide adequate recovery of hot water. This method of heating domestic hot water is quite efficient--only 50% averaged over a year. A recent field survey indicated that the average efficiency of heating hot water alone during the summer was only 18%.

d. What Was Done

We believe it is possible to affect recuctions in fuel oil usage in the Masters' Houses by at least 10% at smal or no cost. We did the following:

1. Studied the available maintenance and tune-up records for the oil burners of the Masters' Dwellings. Obtained consumption records and degree day information. Obtained a K factor* for each house. (Appendiix VIII)

2. Had an independent oil burner company measure furnace performance in 10 houses in March to determine if and by how much performance has deteriorated since the last tune-up. (Appendix IX)

3. On the basis of information derived in steps 1 and 2, recommended a trial reduced nozzle size for each house. The new nozzles can be installed by the regular serviceman on the occasion of the next annual tune-up. (Appendix X)

3. Suggested New Trial Firing Rates

We have seen how excessive firing rates can represent a major loss in an oil burning furnace. Research and field measurements have

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*K Factor: The number of degree days per gallon of fuel oil consumed. Example: A house consuming 1500 gallons of fuel oil in a 6000 degree day heating season would have a K factor of 4 degree days per gallon.

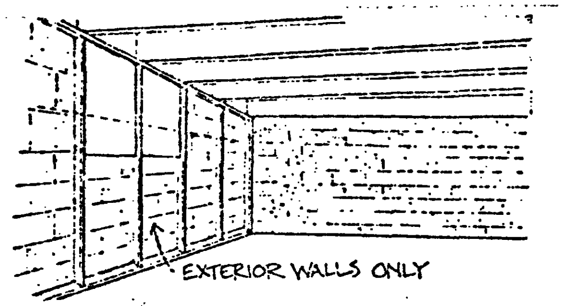
indicated that most furnaces are overfired because pyramiding safety factors have led to overdesigned heating installations.** This is even more often the case where householders hae elected to turn down their thermostats from previous norms to 68°F and possibly also a night set-back to a lower temperature.

A theoretical nozzle size was computed on the basis of K factors provided us by the fuel oil dealer and a 0°F design temperature for the heating system. We know that a change in firing rates will necessarily be an iterative process. We do not suggest changes to firing rates below 0.5 gal/hr even when indicated by the theory because of potential reliability problems with nozzles with very small openings.

**Bonne Ulrich, A.E. Johnson, J. Glatzel and T. Torborg, "Analysis of New England Oil Burner Data: Effect of Reducing Excess Firing Rate on Seasonal Efficiency," Final Report Contract NBS-514736, Honeywell Corporate Research, Bloomington, MN, Aug. 29, 1975.

APPENDIX II

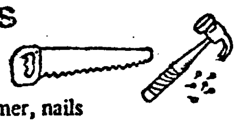
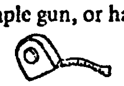
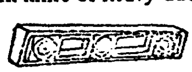
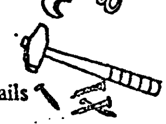
Insulate your Basement Walls - A Moderately Easy Do-It-Yourself Project.



Install 2" X 3" studs along the walls to be insulated. Add glass fiber blanket insulation between the furring strips and finish with wallboard or panelling.

> NOTE: The method of insulation shown here should not be used by residents of Alaska, Minnesota, and northern Maine. The extreme frost penetration in these areas can cause heaving of the foundation if the insulation method shown here is used. Residents of these areas should contact local HUD/FHA field offices for advice.

Tools

1. Saw 
2. Hammer, nails
3. Heavy duty staple gun, or hammer and tacks 
4. Tape measure 
5. Linoleum knife or heavy duty shears 
6. Level 
7. Small sledge hammer, masonry nails 

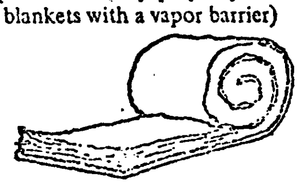
Safety

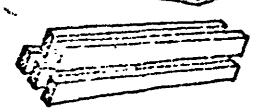
1. Provide adequate temporary lighting
2. If you use glass fiber or rock wool, wear gloves and a breathing mask, and keep the material wrapped until you are ready to use it

Materials

What you'll need

1. R7 (2-2½ inch) Batt or blanket insulation, glass fiber or rockwool, with a vapor barrier (buy polyethylene if you can't get batts or blankets with a vapor barrier)

2. 2" X 3" studs 
3. Dry wall or panelling 
4. Waterproof paint, if necessary 

How much

1. Find the average height above the ground of the walls you intend to insulate and add two feet. Then measure the length of the walls you intend to insulate. Multiply the two figures to determine how many square feet of insulation is needed.

   (height) X (length) = area

   ______ X ______ = ______

2. Find the linear feet of studs you'll need by multiplying the length of the walls you intend to insulate by (6).

   (6) X (length) = (linear ft.)

   (6) X ______ = ______

3. The area of wall covering equals the basement wall height times the length of wall you intend to finish.

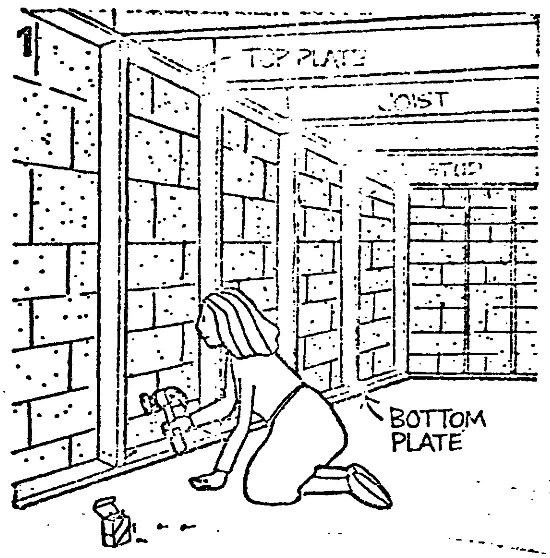
   (height) X (length) = area

   ______ X ______ = ______

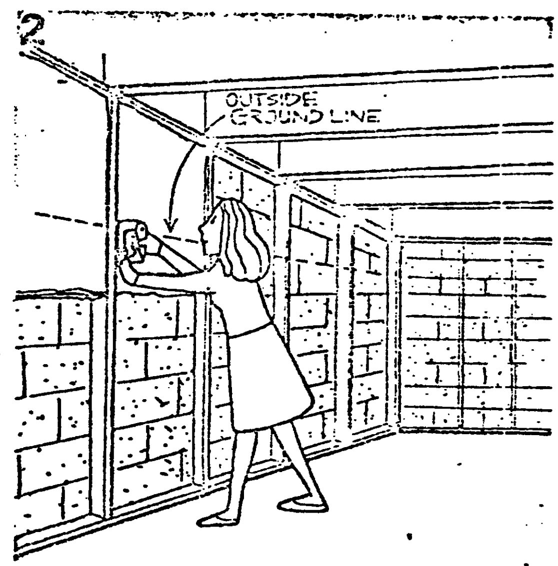
APPENDIX II

Preparation

Check to see whether or not moisture is coming through your basement walls from the ground outside. If it is and you walls are damp, you should eliminate the cause of the dampness to prevent the insulation you're going to install from becoming wet and ineffective.

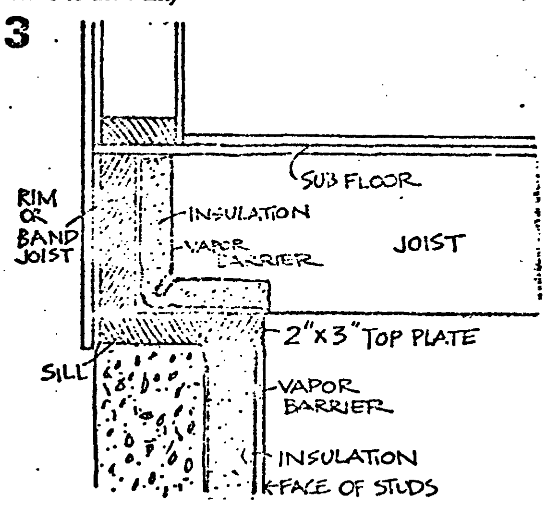


Nail the bottom plate to the floor at the base of the wall with a hammer and concrete nails. Install studs 16 or 24 inches apart after the top plate is nailed to the joists above. (Where the wall runs parallel to the joists, nail the top plate to the tops of the studs, and fasten the studs to the wall.)



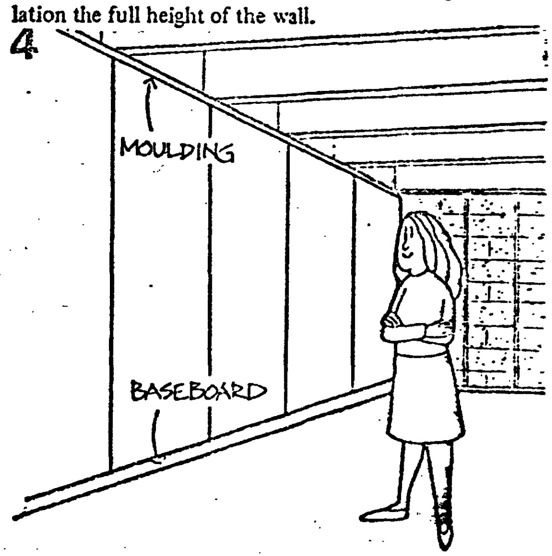
Cut blankets into sections long enough to extend from the top plate to 2 feet below the ground line. Staple them into place between the studs, with the vapor barrier towards the living space. NOTE: in northern climates there will be added benefit to installing the insulation the full height of the wall.

3



Install another small piece of insulation above the furring and against the sill to insulate the sill and band joist.

4



Install finish wall board or panelling over insulation and furring.

APPENDIX III

REDUCE ILLUMINATION LEVELS

Conserve energy for lighting by reducing illumination levels when they need nct be high and eliminating illumination where it is not needed at all. Consult Table 8, "Types of Lighting Compared" for suggested levels in specific areas of the building. If several tasks requiring different levels of illumination occur within the same space, first consider their visual severity and then modify maintenance procedures, redecorate the area, and implement changes to the lighting system while reducing illumination levels to the appropriate level for each task. A uniform modular lighting pattern of general illumination, throwing light equally on all areas regardless of task may waste up to 50% of the energy used for lighting in the building. Orient lighting to suit the tasks to be performed.

If one task with a critical lighting requirement is confined to a specific work area, i.e., drafting table, typewriter, desk top - in the midst of a larger work area with less critical requirements, provide a lower general illumination level for the overall area and a portable light at each critical task to raise the level of illuminatiokn locally (less than $25/lamp). Use fluorescent portable lamps in preference to incandescent.

In many cases it is less costly to move tasks to suit an existing lighting pattern than to add or rearrange fixtures. If task areas are widely dispersed, more light spills into adjoining areas where it may not

	Type & Wattage	Lumens per Watt (L/W)	Life-time	Lumen Efficacy	Equip-ment Cost	Ope-rating Cost	Color Characteristics	Recommended Uses	Remarks
incandescent	Standard 15 25 40 50 75 100 250 500	 8 9 12 14 18 18 20 21	750—1000 hrs: shortest of all lamps	80% prior to failure	Low	High	• Nearest to natural daylight Skin tones heightened. Gives "warm" atmosphere where used	• Where lamps are burned fewer than 6 hrs a day • Where foot-candle requirements are under 50. • Where "warm" atmosphere is desired	• Efficiency is critically dependent on operating voltage. Do not burn lamps at voltages lower than the output of the electrical socket.
	Long-life 100		2, 3, or 5 years		High	High		• Only where maintenance is difficult or irregular	
	PAR 250	18.4		Reduced to 70% after 1,000 hrs.				• As narrowbeam flood-lights • "Cool beam" lamps suitable for displaying food	
	Tungsten Halogen 45 100 150 200 250 Spot 500 Flood 1,000 Flood	 13 18 18 19 13 14 17	4,000 hrs, minimum for high-voltage lamps	90% after 3,000 hrs.	Low	Low	• Good color rendition: bright, white	• Where strong light is desired • Where good color is desired • General lighting for large rooms, production areas • In cornices and niches	• Low wattages available for single-purpose lamps • Not as flexible as standard incandescent • Significant savings in energy and costs over standard incan-descent
	PAR 150			98% after 3,000 hrs.				• For floodlighting and out-door decorative lighting	
fluorescent	40 60 75 110	66 68 73 72	20,000 hrs.	70% at 12,000—15,000 hrs.	Higher than Incand-escent	Lower than Incand-escent	• Warm white has the poorest color rendition; cool and deluxe warm white are better. Deluxe cool white most closely approxi-mates natural daylight	• In production areas, kitchens, offices • As display lighting • Deluxe cool white, deluxe warm, and white can be usually used in place of incandescent bulbs	• Ballasts required for start-up reduce lamp efficiency • Color-corrected lamps are 30% less efficient than standard • Efficiency especially affected by ambient temperature • Cool and warm white have highest outputs, followed by deluxe and color-corrected lamps

Table 8

Types of Lighting Compared

high-intensity discharge

Type & Wattage	Lumens per Watt (L/W)	Life-time	Lumen Efficacy	Equip-ment Cost	Opera-ting Cost	Color Characteristics	Recommended Uses	Remarks
Mercury 40 100 175 250 400	29 41 42 46 51	24,000 hrs.	75% after 16,000 hrs.	Low	Medium	• Available in clear, white, color-corrected, and deluxe white. Deluxe white has best color rendition • Deluxe white is interchangeable with cool white fluorescent	• Indoors to light large spaces such as kitchen and production areas • Outdoors in parking areas and as merchandising or decorative lighting	• Cannot be dimmed; voltage requirements are precise • Not as sensitive to frequent start-ups as fluorescent
Special Mercury 40 75 100	18 36 36	24,000 hrs.	75% after 16,000 hrs.	Low	Medium	• Excellent color; preferred alternative to cool white fluorescent • Second best color choice for "warm" atmosphere	• Can replace incandescent lamps in interior fixtures	• Limited number of sizes; strictly for interior fixtures • Higher wattages and longer life than standard mercury
Metal Halide 175 250 400	70 64 80	7,500–15,000 hrs.	60% after 11,000 hrs.	Medium	Medium	• Better color than mercury; not as good as special mercury • Color-coated bulb has good, warm color; clear bulb less satisfactory • Best color rendition for outdoor lighting	• Parking areas • Large work spaces • Interior spaces lighted from above • Food displays	• Ballast required • Higher lumen output, lower lifetime than mercury
High-pressure Sodium 150 250 400	89 80 106	12,000 hrs. 15,000 hrs. 20,000 hrs.	80% at end of lifetime	High	Low	• Poor color rendition: grays colors of red and blue objects. Similar to warm white fluorescent	• Outdoor; where color is unimportant: in parking spaces and security uses • If illumination of building is enhanced by yellow light	• The most efficient lamp currently on the market

NOTES: Neon lights have not been included because they are commonly used only as decorative lighting.
Fluorescent lamps described are all "rapid start."
Lumen efficiencies and numbers of lumens per watt are approximations.

Table 8 (cont.)

be needed. Group tasks requiring similar lighting levels to limit the spill of higher level illumination and to allow lower lighting levels at less critical work areas.

Light levels in standard footcandles can be determined with portable illumination meters such as a photovoltaic cell connected to a meter calibrated in footcandles. The light meter should be accurate to about ± 15 percent over a range of 30 to 500 footcandles and ± 20 percent from 15 to 30 footcandles. The meter should be color corrected (according to the CIE Spectral Luminous Efficiency curve) and cosine corrected. Generally, measurements refer to average maintained horizontal footcandles at the task or in a horizontal plane 30 inches above the floor.

Measurements should be made at many representative points between and under fixtures; an average of several readings may be necessary. Daylight should be excluded during illumination-level readings for a true determination of level without light contribution from daylight.

The suggested illumination levels for office buildings, listed in Table 8 agree closely with new standards recommended by the U.S. Government Services Administration for public office buildings. Keep in mind, however, that even lighting at lower intensities is very wasteful if lamps are burning when not needed.

SUGGESTED LIGHTING LEVELS*

With proper attention to quality the following levels should generally be adequate for tasks of good contrast:

Circulation Areas between Work Stations: 20 footcandles.

Background beyond Tasks at Circulation Area: 10 footcandles.

Waiting Rooms and Lounge Areas: 10-15 footcandles

Conference Tables: 30 ESI footcandles with background lighting 10 footcandles.

Students/Faculty/Secretarial Desks: 50 ESI footcandles with auxiliary localized (lamp) task lighting directed at paper holder (for typing) as needed.

Over Open Drawers of Filing Cabinets: 30 footcandles.

Kitchens: non-uniform lighting with an average of 50 footcandles.

Cafeterias: 20 footcandles.

Snack Bar: 20 footcandles.

Laboratories: As required by the task, (consider 2 levels, 1/2 and full). In computer areas, reduce general overall lighting levels to 30 footcandles and increase task lighting for critical areas for input. Too high a level of general lighting makes it difficult to read the self-illuminated indicators.

Drafting: Full-time, 80 ESI footcandles at work station, part-time, 60 footcandles at work station.

Accounting Offices: 80 ESI footcandles at work stations.

Note: Where applicable, refer to health and safety codes and federal standards (OSHA) for minimum lighting specifications.

The goal of the above standards is to reduce class and office lighting energy usage to less than 2 watts/sq.ft. gross floor area, or 2.5 watts/sq.ft net area and 1.5 watts/sq.ft for religious buildings. To determine net area subtract from the gross building floor area, the corridors, storage rooms, lobbies, mechanical equipment rooms, stairwells, toilet rooms, and other unoccupied, or seldom occupied areas. Use the following as a guide:

Table 9

Indoor Lighting Survey with Light Meter

Room	No. of Bulbs	Average Wattage	Illumination footcandles	IES Recommended	
				Illumination in footcandles	Lamp Type
Overall					
Work Surface					
At Center					

N.B. 1. Check age of bulbs - new lamps will give different readings

2. Cleanliness of fixture

   Photocell switches to outdoor lighting

3. Replace outside high press sodium lamps with high intensity discharge lamps with same lumen output and also inside deluxe mercury in special places.

4. Use fluorescent inside except for decorative.

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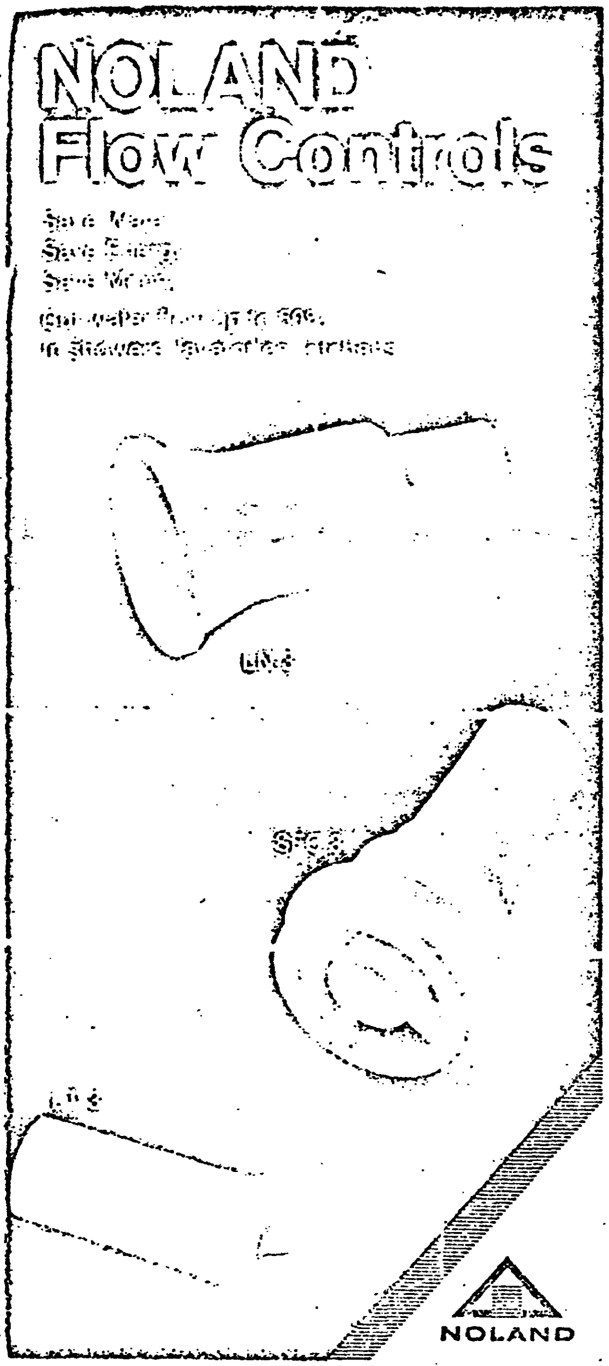
* Unless otherwise noted, all levels are average.

APPENDIX IV



Satisfied Users of NOLAND Flow Controls

Educational Institutions	
Kern High School District	Bakersfield, California
Pennsylvania State University	State College, Pennsylvania
Princeton University	Princeton, New Jersey
University of Nebraska	Lincoln, Nebraska
University of Virginia	Charlottesville, Virginia
Hotels/Motels	
Americana Hotels	Various Locations
Astroworld Hotel	Houston, Texas
Hilton Hotels	Various Locations
Holiday Inns	Various Locations
Howard Johnson Motor Lodges	Various Locations
Williamsburg Inn	Williamsburg, Virginia
Government	
Cherry Point Marine Air Station	Cherry Point, North Carolina
Defense Construction Supply Center	Columbus, Ohio
Department of Environmental Resources	Harrisburg, Pennsylvania
Oceana Naval Air Station	Virginia Beach, Virginia
Property Management	
Allen & O'Hara, Inc.	Memphis, Tennessee
Housing Authority of Milwaukee	Milwaukee, Wisconsin
Norfolk Redevelopment & Housing Authority	Norfolk, Virginia
Virgin Islands Housing Authority	St. Thomas, V. I.
Utilities	
Monte Vista County Water District	Montclair, California
Muskingum Watershed Conservancy District	New Philadelphia, Ohio
North Tahoe Public Utility District	Tahoe, California
Washington Suburban Sanitary Commission	Hyattsville, Maryland

For More Information on NOLAND Flow Controls, Contact:

Noland Company
National Accounts Department
2700 Warwick Blvd.
Newport News, Va. 23607
(804) 247-0116

NOLAND LN-3 Flow Control

For Lavatory & Sink Faucets With Solid Shanks

Save Water and Energy in Bathrooms, Kitchens

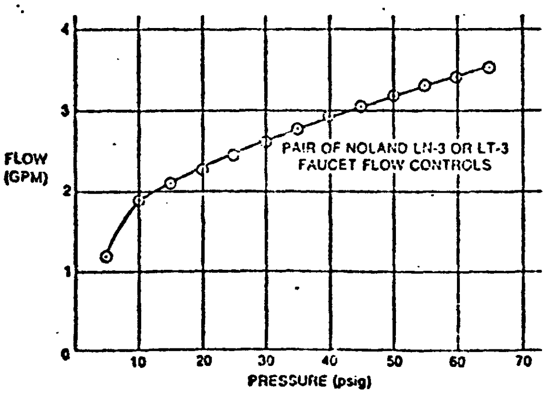
A typical lavatory or kitchen faucet uses 5 to 7 gallons of water per minute. Noland LN-3 flow controls are specially engineered to reduce the flow through lavatory or kitchen faucets to 3 G.P.M., while maintaining a spray pattern that's sufficient for normal lavatory or kitchen sink uses. Since much of the water used in lavatory and kitchen faucets is hot water, you get a double saving—both in total water consumption and in energy used for heating the hot portion of the water saved.

Improved Connection Between Supply Tube and Faucet

Noland LN-3 controls are designed to fit into the shanks of lavatory and kitchen faucets, one in the cold side and one in the hot side. They actually improve the connection between the supply tubes and the faucet shanks, because metal-to-metal contact is eliminated and proper alignment is assured by the shape of the flow control. The installer also has the option of using either straight supply tubes or supply tubes with formed nosepieces, as the LN-3 is designed to make a leak-proof connection with either type.

Pressure-Compensating Feature

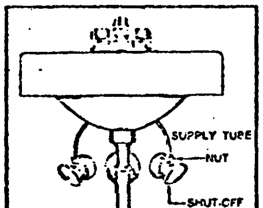
As shown in the flow chart below, the Noland LN-3 compensates for fluctuations in pressure. A pair of LN-3s deliver 3 G.P.M. at a pressure of 45 PSI. As pressures rise above 45 PSI, the LN-3 controls compensate for these changes, and flow rate through the controls increases only very slightly.



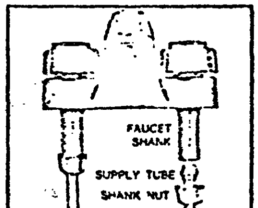
Installation Instructions

Install a pair of flow controls (one in hot side, one in cold side) using these simple steps:

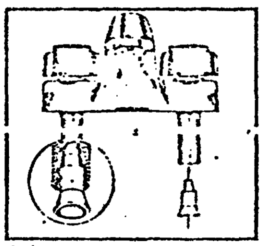
1. SHUT OFF MAIN WATER SUPPLY



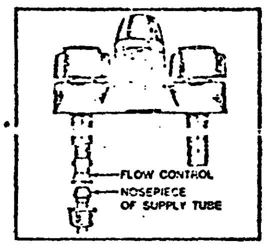
2. Loosen coupling nut on shut-off valve and disconnect bottom of supply tube from shut-off valve.



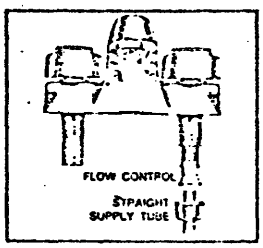
3. Loosen shank nut and disconnect top of supply tube from faucet shank.



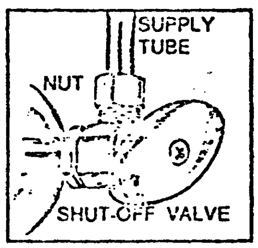
4. Insert narrow end of flow control into faucet shank.



5. WHEN USING SUPPLY TUBE WITH FORMED NOSEPIECE: Insert nosepiece of supply tube into flared end of flow control. Tighten shank nut to reconnect top of supply tube to faucet shank.



6. WHEN USING STRAIGHT SUPPLY TUBE: Insert top of supply tube as far as possible into narrow section of flow control. Tighten shank nut to reconnect top of supply tube to faucet shank.



7. Reconnect bottom of supply tube to shut off valve and turn on water supply.

NOLAND SFC-3 Shower Flow Control

A Low-Cost, Pressure-Compensating Flow Control

Noland's SFC-3 is a simple, but highly engineered, three-chambered Celcon cylinder with no moving parts. Non-clogging, it regulates the flow of water at a predetermined rate and automatically compensates for varying pressures.

Cuts Water Flow by 50% or More

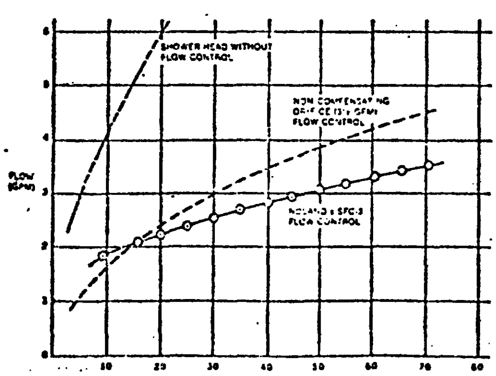
Noland's SFC-3 reduces the maximum flow of water through a ½" I.D. shower arm from the normal 7 to 10 G.P.M. to 3, conforming to latest plumbing code restrictions. While the volume of water is substantially reduced, the output quality of the shower head is maintained. The SFC-3 will operate effectively at any temperature above the freezing point of water and below its boiling point.

Thoroughly Tested by Virginia Tech

The graph below shows the results of performance tests conducted by the Virginia Polytechnic Institute & State University Industry Center. It compares flow rates through a shower head:

- with no flow control
- equipped with Noland's SFC-3
- equipped with a non-compensating (orifice) flow control.

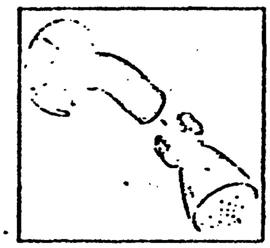
VPI stated, "As a result of our tests, we have concluded that the modified nozzle (Noland's SFC-3) is a definite improvement over the orifice type. We believe that it is a simple and effective method of reducing the flow rate to conserve energy and reduce the sewage problem."



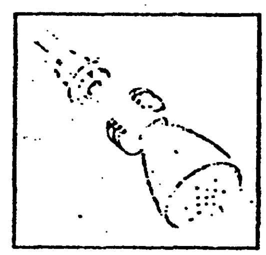
Easily & Quickly Installed

Inserts smoothly into either the upstream or downstream end of ½" I.D. shower arm. The standard installation can be made by either a plumber or homeowner in a matter of minutes.

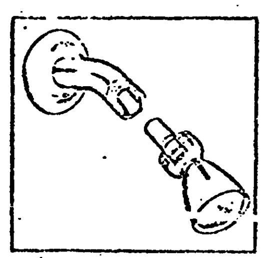
Standard Installation Instructions



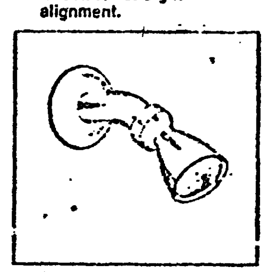
1. Remove shower head from threaded shower arm.



2. Insert flanged end of flow control into shower head. Check for straight alignment.



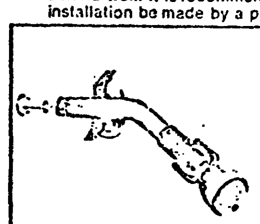
3. Insert narrow end of flow control into shower arm until shower head threads engage shower arm threads.



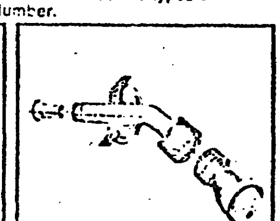
4. Thread shower head onto shower arm by hand, then tighten with an adjustable wrench.

Vandal Proof or Integral Ball Joint Installation

Insert unit into the upstream end of shower arm as shown behind wall. It is recommended that these two types of installation be made by a plumber.



Vandal Proof



Ball Joint

NOLAND LT-3 Flow Control For Lavatory & Sink Faucets With Copper Tube Inlets

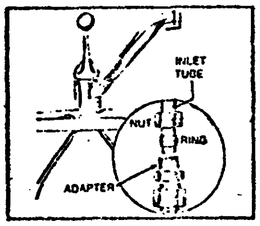
LT-3 Controls Specially Designed for Copper Tube Inlets

Noland LT-3 flow controls are specially designed to fit faucets with copper tube inlets and provide the same great water savings that the LN-3 controls do. Flow rate through a faucet equipped with a pair of LT-3 controls is 3 G.P.M. at 45 PSI, as shown in the chart on page 4.

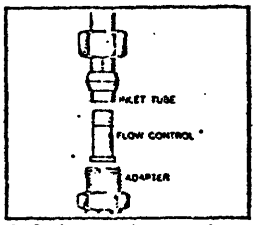
Installation Instructions

Install a pair of flow controls (one in hot side, one in cold side) using these simple steps:

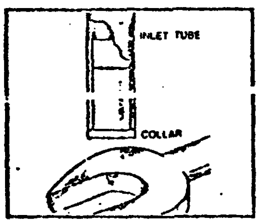
1. SHUT OFF MAIN WATER SUPPLY.



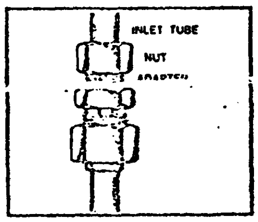
2. Loosen compression nut from top of adapter and slide nut and ring up faucet inlet tube.



3. Spring top of adapter free from bottom of faucet inlet tube. Insert narrow end of flow control into faucet inlet tube.



4. Press or lightly tap flow control until bottom of faucet inlet tube is flush with collar of flow control.



5. Slide compression nut and ring down to bottom of faucet inlet tube, insert inlet tube into top of adapter, and tighten compression nut. Turn on water supply.

Alternate Installation Method

As an alternative to installation in the faucet inlet tubes, a pair of LT-3 controls can be installed in the bottom of the supply tubes using these simple steps:

1. SHUT OFF MAIN WATER SUPPLY.
2. Loosen compression nut on shut-off valve and disconnect bottom of supply tube from shut-off valve.
3. Insert narrow end of flow control into bottom of supply tube. Press or lightly tap flow control until bottom of supply tube is flush with collar of flow control.
4. Reconnect bottom of supply tube to shut off valve and turn on water supply.

NOLAND LT-3 Flow Control For Lavatory & Sink Faucets With Copper Tube Inlets

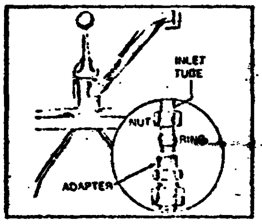
LT-3 Controls Specially Designed for Copper Tube Inlets

Noland LT-3 flow controls are specially designed to fit faucets with copper tube inlets and provide the same great water savings that the LN-3 controls do. Flow rate through a faucet equipped with a pair of LT-3 controls is 3 G.P.M. at 45 PSI, as shown in the chart on page 4.

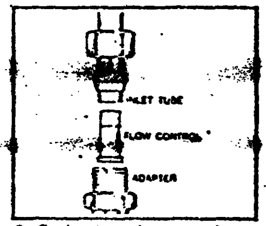
Installation Instructions

Install a pair of flow controls (one in hot side, one in cold side) using these simple steps:

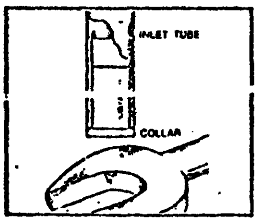
1. SHUT OFF MAIN WATER SUPPLY.



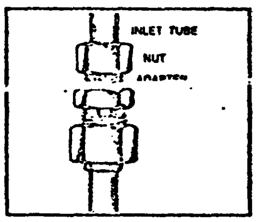
2. Loosen compression nut from top of adapter and slide nut and ring up faucet inlet tube.



3. Spring top of adapter free from bottom of faucet inlet tube. Insert narrow end of flow control into faucet inlet tube.



4. Press or lightly tap flow control until bottom of faucet inlet tube is flush with collar of flow control.



5. Slide compression nut and ring down to bottom of faucet inlet tube, insert inlet tube into top of adapter, and tighten compression nut. Turn on water supply.

Alternate Installation Method

As an alternative to installation in the faucet inlet tubes, a pair of LT-3 controls can be installed in the bottom of the supply tubes using these simple steps:

1. SHUT OFF MAIN WATER SUPPLY.
2. Loosen compression nut on shut-off valve and disconnect bottom of supply tube from shut-off valve.
3. Insert narrow end of flow control into bottom of supply tube. Press or lightly tap flow control until bottom of supply tube is flush with collar of flow control.
4. Reconnect bottom of supply tube to shut off valve and turn on water supply.

Figure 26

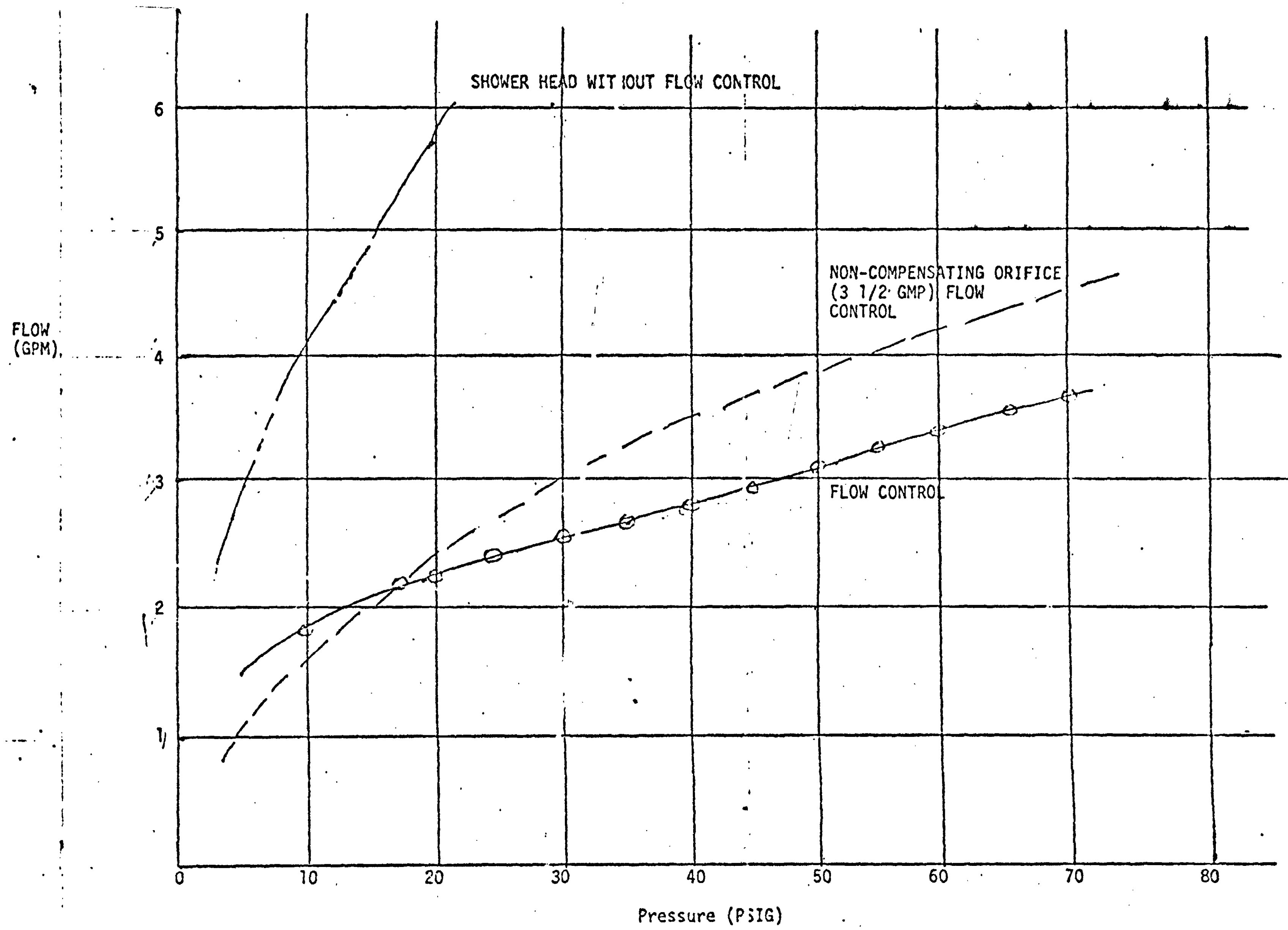


Figure 26 Change in Water Flow with Control Inserted