

Measure Information Template

PEX Parallel Piping Hot Water Distribution Systems

2008 California Building Energy Efficiency Standards

Davis Energy Group, Inc (April 19, 2006)

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Purpose

This document proposes mandatory changes to the installation requirements for PEX parallel piping hot water distribution systems. These systems are increasingly commonly used in production housing to deliver hot water from the water heater, through a distribution manifold, and ultimately to hot water use points. Current eligibility criteria for parallel piping systems are not sufficiently explicit in defining an acceptable installation.

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Overview

<p>Description</p>	<p>Parallel piping (or “home run”) hot water distribution systems typically feature a distribution manifold in close proximity to the water heater. The manifold is fed by a larger diameter pipe, typically cross-linked polyethylene (PEX) plastic piping. Although some plumbers will combine two low flow rate fixtures with a single line (e.g. neighboring bath sinks), the more common application involves individual small diameter PEX tubing (typically 3/8” or 1/2”) running from the manifold to each hot water use point. The primary advantages of parallel piping PEX manifold systems are:</p> <ol style="list-style-type: none"> 1. Lower material cost (lower and more stable pricing than copper) 2. Easier and cheaper installation (no soldering) 3. Greater reliability (utilizes crimp connectors, less likely to leak) <p>In addition, in well designed and installed systems, parallel piping systems can offer lower distribution system energy losses and shorter waiting times than standard trunk and branch installations. Despite these benefits, a recent PIER-funded field study of sixty hot water distribution systems found that parallel piping systems are often not installed in a manner that insures that optimal performance. This template proposes the following two mandatory measures that will significantly improve the performance and customer satisfaction with parallel piping systems:</p> <ol style="list-style-type: none"> 1. Limiting the water heater to manifold piping distance to ten feet 2. Require minimum R-4 pipe insulation on the pipe run between the water heater and manifold. <p>This proposal is for all building types included under the residential standards.</p>
<p>Type of Change</p>	<p>The proposed change is suggested as a Mandatory Measure. Section 150 of the Building Standards would be affected.</p>
<p>Energy Benefits</p>	<p>The proposed changes would reduce the volume of water in the line between the water heater and the manifold by roughly 50%. Simulation projections estimate the hot water distribution savings at about 30-40% relative to standard parallel piping practice. Annual energy savings are estimated at 11 to 19 therms.</p>
<p>Non-Energy Benefits</p>	<p>The primary non-energy benefit is reduced hot water waiting time. The proposed measure is estimated to reduce the average volume of water between the water heater and the hot water fixtures by ~25%. This equates to reduced hot water times for the consumer and less water wasted at the end use point.</p>
<p>Environmental Impact</p>	<p>The proposed measure has no negative environmental impacts. Benefits include reduced water consumption, reduced material consumption (~10 foot reduction in pipe length), and improved air quality due to natural gas savings.</p>

Technology Measures	<p>Measure Availability and Cost</p> <p>There are numerous manufacturers of pipe insulation including ThermaCel, Insul-tube, and FlexTherm. The impact of this proposal on the market is negligible since it will require addition of less than 10 feet of pipe insulation per parallel pipe system.</p> <p>Useful Life, Persistence and Maintenance</p> <p>There are no issues related to this topic area. The pipe insulation is in a protected environment.</p>
Performance Verification	The 10' maximum pipe length and insulation requirements are easily observable by the building inspector.
Cost Effectiveness	The proposed mandatory measures are cost-effective since the projected benefits (reduced gas consumption and reduced PEX piping) are considerably greater than the added cost of the insulation. In addition, customers will see a significant improvement in hot water delivery characteristics.
Analysis Tools	The HWSIM distribution system simulation model (used in developing the 2005 distribution system multipliers) was used to assess cost-effectiveness.
Relationship to Other Measures	No significant impact on other measures.

Methodology

The California Energy Commission’s PIER program is currently supporting water heating research that will support Title 24 Standards development in both 2008 and beyond. One element of the research involved a field survey of the hot water distribution systems (HWDS) in sixty California production homes currently under construction. Davis Energy Group, Inc. and Chitwood Energy Management (under the direction of Lawrence Berkeley National Laboratory) completed this work effort in early 2006. The sixty homes comprised the work of 19 different plumbers and ranged geographically from Redding to Costa Mesa. The goal of the study was to document current hot water plumbing practice for a full range of common system types being installed. Key information gathered included:

- HWDS type (e.g. trunk and branch, parallel piping, recirculation)
- Materials used (copper, PEX, other)
- Pipe lengths, diameters, and location (attic, underslab, interior cavity, exterior wall, garage)
- Characterize hot water end use points (showers, sinks, lavs, etc)

Details of the methodology and results can be found in the Subtask 2.3 report entitled “Field Survey Report: Documentation of Hot Water Distribution Systems in Sixty New California Production Homes”.

It became apparent during the course of the fieldwork that parallel piping systems with PEX piping have become considerably more popular among production builders in recent years. Of the 60 sites in the field survey, 23 sites were found to have parallel piping systems with PEX tubing and a central manifold. The primary driving force for these systems appears to be first cost, ease of installation, and reliability of plumbing connections (no soldering, continuous pipe run from manifold to use point). Figure 1 shows how some plumbers utilize truck-mounted rigs to easily pull the 3/8” and 1/2”

PEX lines from the manifold to the hot water use points. Figure 2 shows a manifold installed in a framed assembly on the garage wall drywall¹. Although some plumbers will “double up” low flow fixtures (e.g master bath dual sinks), the more typical installation involves individual hot water lines run to each use point. The smaller diameter lines combined with thicker PEX pipe walls (~35% less volume per foot) means less water in the lines and shorter waiting times.

One key observation in documenting the parallel piping installations in the field was the inefficiency in running the ¾” or 1” PEX main line from the water heater to the manifold. For the 23 parallel piping sites, the average length of pipe running from the water heater to the manifolds was 20.2 feet, despite the fact that in almost all cases the water heater was less than five feet (in plan view) from the manifold.

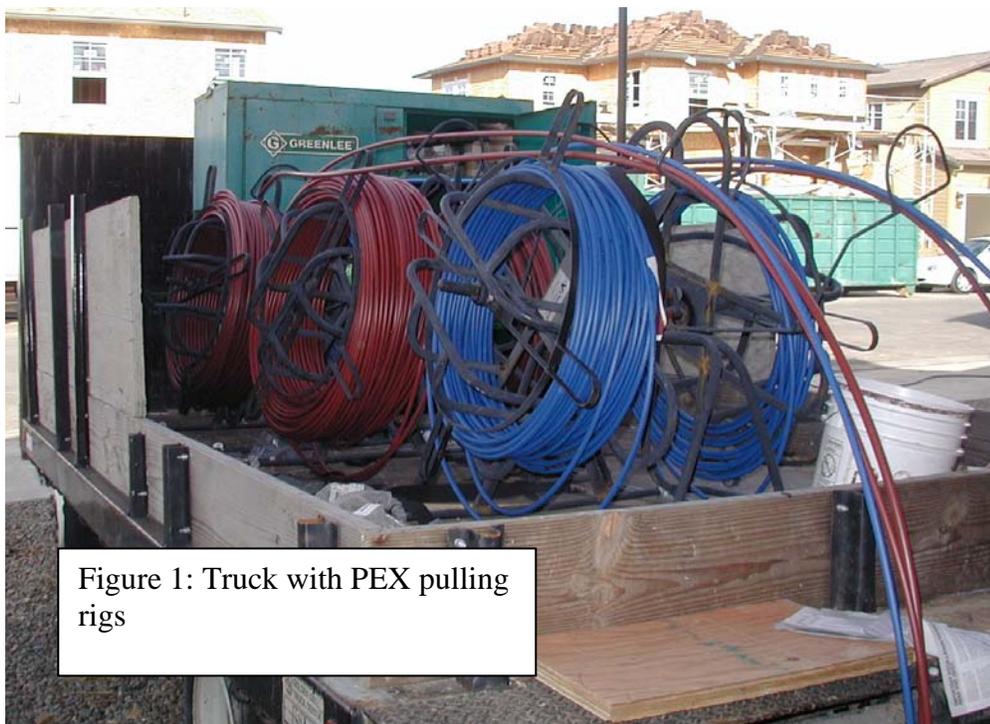


Figure 1: Truck with PEX pulling rigs

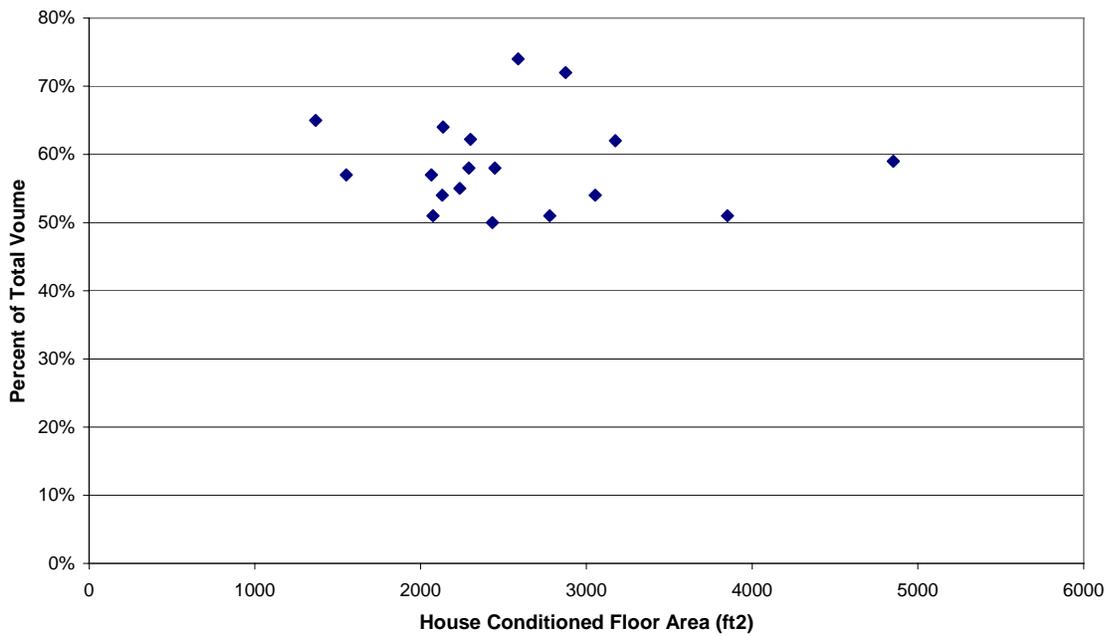
Figure 3 plots the volume of water entrained in the main line (water heater to manifold) as a percentage of the average amount of entrained water to each fixture in the house. On average, an astounding 61% of the total volume of the parallel piping systems was determined to be in the main line. Clearly, reducing the entrained volume in this line would significantly improve distribution system performance and reduce homeowner hot water wait times. In addition, insulating the main line would significantly increase the amount of time water in the main line would remain usable for subsequent draws. With input from Rick Chitwood (who completed the field survey work) and several plumbers, we determined that a 10 foot “water heater to manifold” maximum piping length could easily be achieved.

¹ The manifold is framed out to avoid penetrating the fire wall.



Figure 2: Installed manifold framed out on garage wall with hot (red) and cold (blue) piping

Figure 3: Observed Parallel Piping System Characteristics - Entrained Volume (Water Heater to Manifold vs. Total Volume)



Analysis and Results

The HWSIM hot water distribution system model was used to evaluate the benefits of the two measures. HWSIM has previously been used in the development of the original 1991 Title 24 water heating methodology and the development of the distribution system multipliers for the 2005 Standards. The benefit of shortening and insulating the main line is directly a function of how much hot water flows from the water heater through the manifold and the timing between draws. To evaluate the impact, the assumed hot water loads profile used for a 2,010 ft² single-story house (used in the 2005 Standards development) were used to evaluate the following options²:

- 20.2' of 1" PEX main line, uninsulated
- 10' of 1" PEX main line, uninsulated
- 10' of 1" PEX main line, insulated to R-4
- 20.2' of 3/4" PEX main line, uninsulated
- 10' of 3/4" PEX main line, uninsulated
- 10' of 3/4" PEX main line, insulated to R-4

The benefits of reducing the length of the main line and also insulating the line is comprised of energy savings, piping material savings, water savings, and improved customer satisfaction. For this conservative analysis only the value of the energy savings were quantified. Gas savings were computed using the prescribed value of \$.24374 per kBtu, or \$24.374 per therm. Table 1 presents the HWSIM projections for distribution losses for the six cases in the first column. The second column calculates energy water heating energy savings based on an assumed 80% water heater recovery efficiency³.

Table 1: Projected Energy Savings

	Annual Distribution Loss (therms/year)	Distribution Loss Reduction (therms/year)
1" Main Line		
20.2' uninsulated	38.3	n/a
10' uninsulated	27.5	13.5
10' insulated to R-4	23.4	18.6
3/4" Main Line		
20.2' uninsulated	30.4	n/a
10' uninsulated	23.8	8.3
10' insulated to R-4	21.7	10.9

² Both 3/4" and 1" PEX mainlines were modeled since they are both commonly found in the field.

³ The vast majority of gas storage water heaters installed in new homes have a 76% recovery efficiency. Higher efficiency storage water heaters and instantaneous gas water heaters have recovery efficiencies in the low 80's%.

Pipe insulation costs were conservatively based on Grainger's retail pricing for closed cell 1" pipe insulation (\$1.06 per foot) and estimated labor costs of \$.75 per foot⁴. Table 2 summarizes the costs and benefits of the insulating the main line. The benefit-cost ratio is significantly greater than one in both cases, without accounting for the additional energy savings due to shortening the main line.

Table 2: Cost-Effectiveness Calculations

	Annual Savings (therms/year)	Present Value Benefits (\$)	Present Value Costs (\$)	Benefit-Cost Ratio
1" Main Line	5.1	\$125	\$18	6.9
3/4" Main Line	2.6	\$64	\$18	3.5

Recommendations

The proposal for improving parallel piping HWDS performance by limiting water heater to manifold length and requiring insulation on the line has very favorable economics. Additional non-quantified benefits of reduced water consumption, reduced piping material needs, and increased homeowner satisfaction (reduced distribution losses and hot water waiting times) all point to a strong endorsement for this proposal to become a mandatory measure.

Material for Compliance Manuals

The following change, highlighted in blue, is proposed for the Building Energy Efficiency Standards (Subchapter 7, Section 150 (j) 2).

(j) **Water System Pipe and Tank Insulation and Cooling Systems Line Insulation.**

1. **Storage tank insulation.**

- A. Storage gas water heaters with an energy factor < 0.58 shall be externally wrapped with insulation having an installed thermal resistance of R-12 or greater.
- B. Unfired hot water tanks, such as storage tanks and backup storage tanks for solar water-heating systems, shall be externally wrapped with insulation having an installed thermal resistance of R-12 or greater or have internal insulation of at least R-16 and a label on the exterior of the tank showing the insulation R-value.

2. **Water piping and cooling system line insulation thickness and conductivity.** Piping, whether buried or unburied, for recirculating sections of domestic hot water systems; piping from the heating source to the storage tank for an indirect-fired domestic water-heating system; the first five feet of hot and cold water pipes from the storage tank for nonrecirculating systems; **the entire length of the water heater to manifold piping in parallel piping hot water distribution systems (maximum piping length of ten feet) ;** and cooling system lines shall be thermally insulated as specified in Subsection A or B. Piping for steam and hydronic heating systems or hot water systems with pressure above 15 psig shall meet the requirements in **Table 123-A.**

⁴ Plumber estimate of 80 feet of pipe insulation per hour at a fully loaded \$60 labor rate.

Bibliography and Other Research

The analysis presented here is based largely on field measurements completed under the ongoing PIER-sponsored hot water “Water Heater and Hot Water Distribution Systems Project”. The report entitled “Field Survey Report: Documentation of Hot Water Distribution Systems in Sixty New California Production Homes” (dated March 21, 2006) is available from Energy Commission project manager Martha Brook.

HWSIM was developed under a 1989 Energy Commission contract to develop a detailed water heating methodology for the Title 24 Residential Standards. HWSIM was used again to update the 2005 hot water distribution system multipliers that credit or penalize various distribution system options.

Appendix A: Photos of Typical Parallel Piping Installations

The following two photos chronicle typical installation practice for parallel pipe manifold systems. Figure A-1 shows the garage-side view of the manifold and water heater located in close proximity. Figure A-2 shows the house-side view of the same wall section. The hot and cold water lines from the water heater (right hand side of photo) rise up into the attic before dropping down to the manifold. This particular installation is fairly length-efficient compared to a majority of the 23 manifold systems observed in the field survey. Many systems had a large loop in the attic prior to dropping down to the manifold. On average the length of main line piping from water heater to manifold was 20.2 feet.



Figure A-1:
Installed Manifold
System



Figure A-2: Back
Side view of Manifold
System with Piping
from Water Heater