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# Final Report

# New Construction Duct Leakage Diagnostic

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*Summary*

The objectives of this project were to develop and test a simplified duct-leakage measurement technique that could be used as part of both new-construction and retrofit DSM programs for residential duct systems. This effort, funded by Southern California Edison through the California Institute for Energy Efficiency, addresses two principal issues: 1) the need for a quick accurate duct-leakage diagnostic, and 2) the need for a technique that can be used prior to dry-wall installation. The technique developed involves direct pressurization of the duct system, and is similar to a technique used by SMACNA. Field tests suggested that the technique could be used in two to five houses per day, and suggested that approximately 50% of the leaks in a typical duct system could be sealed within half an hour. The technique was applied in thirty houses, whose ducts were found to be tighter than those in earlier field studies of existing houses, however it remains unclear as to why they were tighter.

*Background*

The impacts of leaky residential duct systems, and the potential energy savings associated with tightening those duct systems have been noted in numerous studies. Southern California Edison would like to realize some of those savings in the new houses being constructed within their service territory. As much of the leakage problem has been attributed to poor installation practices, testing seems to be an important component of any program designed to reward builders for tighter duct systems. In existing construction, the standard practice is to measure duct leakage before and after sealing using one of several techniques associated with a blower door. The same technique could be used in new construction, however it seems more practical, and more enticing to the HVAC contractors to have a leakage test that could be performed right after installation, which most often occurs prior to installation of drywalls. The advantages of this approach are: 1) that the test can be performed while the installers are still at the site, and 2) that sealing to improve air-tightness is easier while the duct system is more accessible. The disadvantage is that the standard duct leakage measurement techniques based upon a blower-door will not work without drywalls. The objectives of this project were to develop and field test a duct-leakage measurement technique that could be used for new-construction programs that reward airtight duct construction.

*Measurement Technique*

The measurement technique developed is essentially equivalent to the technique specified in the SMACNA HVAC Air Duct Leakage Test Manual. The principal difference between the two techniques is that the technique employed uses multiple pressure measurement sites to assure an accurate assessment of the pressure differential across the leaks. In a relatively tight duct system without significant internal resistances (e.g., dampers), the two techniques should be essentially indistinguishable. The technique developed involves sealing all of the duct-system registers except for one, to which a flexible hose from the blower/flow-measurement device is connected. The pressure in the duct system was measured at the connection of the flexible hose to the ducts, at the supply plenum, and at the supply registers furthest from the supply plenum. Flows and pressures were measured at five pressures between 10 and 50 Pa.

The experimental apparatus developed was based on a rotating-vane anemometer and electronic pressure transducers.Although the precision and accuracy of this device are very good, it would be too expensive to be used on a widespread basis. However, since the time when the experiments were performed, several blower-door manufacturers have started producing practical inexpensive devices for making these measurements.

### *Results*

The measurement technique was applied in 20 houses in southern California, and was subsequently applied to 10 additional houses in the San Francisco Bay Area by a Pacific Gas & Electric contractor that had been trained by Lawrence Berkeley Laboratory staff. In each of the houses, a leakage test was performed either on the supply-ducts only, or on the entire system, depending on the type of installation, and the construction process. Many houses had unducted returns, the leakage of which could not be measured with this technique. After the initial leakage measurement, approximately 30 man-minutes were spent sealing leaks in approximately three quarters of the southern California houses. Due to the fact that the technique developed does not measure the leakage of the seam between the register boots and the floor or dry-wall, the technique was applied to an existing house to obtain a rough estimate of the expected magnitude of this bias between the direct-pressurization technique and the blower-door techniques. The tests in that house included differential sealing and measurement in three phases: 1) supply-register boots, 2) the return-register boot, and 3) plenum leaks.

For all measurements the air-tightness yardstick used to report the results is the effective leakage area at 25 Pa. Effective leakage area was chosen because it expresses the leakage in terms of a physical area, and 25 Pa was chosen instead of the standard 4 Pa reference because the typical pressure across duct leaks is closer to 25 Pa, and the flow at 25 Pa is better determined than that at 4 Pa.In a production situation (e.g., as part of a utility program) a single flow measurement at 25 Pa should prove adequate. Moreover, a single pressure measurement at the supply plenum should also prove adequate in such an application, as long as there isn't a supply damper in the duct to which the blower is connected. The results of the field tests are summarized in Tables 1 and 2.

**Table 1: Leakage Measurement Results (Pre-Sealing Effective Leakage Area at 25 Pa)**

| Sample | Mean [$cm^2$] | Median [$cm^2$] |
|---|---|---|
| 14 SCE Houses Supply Only | 37 | 39 |
| 10 Oakley Houses Supply Only | 20 | 20 |
| 28 Phase-I Houses Supply Only | 84 | 77 |
| Boots to Floor in 1 Phase-I House | 18 | |

**Table 1: Leakage Measurement Results (Pre-Sealing Effective Leakage Area at 25 Pa)**

| Sample | Mean [cm$^2$] | Median [cm$^2$] |
|---|---|---|
| 6 SCE Houses Supply/Return | 76 | 64 |
| 28 Existing Houses Supply/Return | 175 | 149 |

**Table 2: Leakage Sealing (Effective Leakage Area at 25 Pa)**

| Sample | Mean [%(cm$^2$)] | Median [%] |
|---|---|---|
| 9 Southern California Houses Supply Only (25 minutes) | 37 (9) | 42 |
| 5 Southern California Houses Supply/Return (45 minutes) | 56 (45) | 54 |
| 1 Existing House (1.5 Hours) | 38 (62) | |

*Conclusions*

In conclusion, the measurement results from this project suggest several things: 1) duct leakage testing can be performed at a 2-5 house per day throughput level in new construction, 2) the new-construction duct systems were tighter than the recently constructed existing homes measured in an earlier study of California houses, 3) an average of 50% duct-leak sealing could be accomplished in approximately 30 man-minutes, and 4) the use of unducted returns is a significant handicap to the utility of the direct pressurization technique developed, as return leakage is usually larger than supply leakage (particularly for unducted returns) and supply-only leakage sealing was the least cost-effective in terms of absolute leakage sealed per unit time. It is worth noting that the leakage of the pre-drywall houses tested was significantly lower than that measured in ostensibly similar houses less than ten years after completion of construction. It should also be noted that the HVAC contractors for the Oakley homes had been given some guidance and incentive to make more airtight installations, however the southern California contractors had not received any training or incentives. This result suggests some further investigation, as the difference could be simply random, the reduced leakage of the Oakley homes could be due to the training, or both the Oakley and southern California data could indicate that degradation of performance occurs rather rapidly after duct installation, either due to the continuation of the construction process, or due to rapid deterioration of the seals. Similarly, the issue of supply and return boot leakage may also need some additional investigation, as these leaks are not measured by the technique developed. On the other hand, these leaks are easily accessible after construction.Finally, the most important conclusion is that the technique developed could be reasonably incorporated into a utility program to provide incentives for air-tight duct systems in new houses, particularly if ducted returns were an additional requirement of such a program.