Corrected copy, and 5/31/84

May 17, 1984

Mr. Robert N. Kascsak, Manager
Nuclear Systems Engineering Division
Long Island Lighting Company
Post Office Box 618
North Country Road
Wading River, New York 11792

Dear Mr. Kascsak:

Attached is my report of the Delaval foundry heat made on May 2, 1984 and my examination of the gray iron block which was poured for LILCO.

In summary, I observed the furnace charge, melting, and casting procedures; they were representative of very good current practice which would result in an excellent casting, metallurgically. Chemical analysis of the ladle of molten iron from which the block was poured, after additions had been made, showed satisfactory composition. Photomicrographs will be provided by Delaval, as will results of mechanical testing of the test bars.

I inspected the block after cleaning (but before painting) on May 11. With the exception of one gate break-in, the casting appears to be excellent. It is well formed, without holes, cracks, shrinkage or inclusions; it has been thoroughly cleaned and minor fins, veins, and burnt on sand carefully ground off.

The gate break-in on the lower flange, camshaft side, between #3 and #4 cylinders, appeared to have no cracks radiating from it; and can be ground smooth to eliminate possible notch effects. The integrity of the flat sealing surface of the flange is not violated by the break, and its location between flange bolt holes and in front of a major reinforcing

member, plus the machining stock which will be removed from the flange, make its effect on the casting probably insignificant, in my opinion. A review of design stresses in this area should be made to ascertain this.

Some defects, such as microporosity, carbon flotation, and slag inclusions, are often not visible on as-cast surfaces, but can be seen after machining. I will inspect the casting for those defects at that time, if you so desire. Please give me as many days' notice as possible if you want me to do this. I will be out of town for 9 days, June 1-10, but can be reached at 919-986-2503 during that time.

Very truly yours,

C. R. Isleib, P.E.
N.J. Reg. No. 13386
CRI:EMW
Enc.

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PREFACE

LILCO commissioned the writer to observe and review Delaval heat 615K and to inspect the 8-cylinder diesel engine block poured from that heat. This included a review of the furnace charge, observation of the heat in progress, melt and ladle additions, tapping, and casting; discussions with foundry and quality assurance management regarding quality control and inspection procedures; and visual inspection of the cleaned casting. The iron was to conform to ASTM Standard Specification A 48, Class 4~~0~~.
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CONCLUSIONS - MELTING AND CASTING

Melting and Casting

1. The furnace charge was made up of good quality virgin materials and scrap of known composition. I saw no purchased motor blocks, valves, heads or other scrap which might contain lead, zinc, tin or aluminum inserts which could be deleterious to the graphite or matrix structures or castability of the iron.

2. The meltdown of the 23-ton heat began at 4:00 A. M., May 2, 1984; tapping time was 8:48 A. M. Maximum temperature reached in the furnace was about 2750F; tapping temperature was about 2600F; both measured by immersion thermocouple. This is acceptable good practice and should result in minimum gas in the metal and a well-defined, complete casting.

3. The heat was tapped into one 30-ton bottom-pour ladle which had been preheated to red heat. Ladle additions of Graphidox and Z180 were made during the tap for graphitizing purposes. No delays were encountered; tapping was clean and completely satisfactory.

4. Casting was begun promptly at about 2600F; no stopper trouble was encountered, and the mold was filled in under 2-1/2 minutes, a very good time for this size casting. An in-mold graphitizing block is normal practice at DeLaval, to minimize inoculation fade.

5. All mold vents were lit off; no gas explosions occurred; and the risers all fed, judging from examination of the mold later in the morning.

6. It was reported by Superintendent Dobrec that one-, two-, and 3-inch test bars were cast integrally in the mold, off the same gating system, and cooled in the mold along with the casting. Separately cast specimens were also poured.

7. Samples for spectrographic analysis were poured as the heat approached finishing and just before tapping. The final ladle analysis is shown below.

COMMENTS:

The furnace used was a 30-ton capacity three-phase direct arc furnace, acid-lined, rated at 10 tons per hour melting rate. The charge for heat 615K was as follows:

Charge

Charge	Lbs.
Deleval gray iron returns (all shop scrap)	18,400
Structural steel plate, etc.	13,800
Sorel metal pig (4.3 C, 0.2 Si, 0.01 Mn, 0.03 P, 0.02 S)	6,900
Brazilian Foundry pig (0.065 P)	6,900
High Carbon Ferromanganese	170
Graphite	460
Molybdenum oxide briquettes (50% Mo)	175
Ferromolybdenum (62% Mo)	37
Total	46,842

Ladle Additions

SL80 Graphitizer (80% silicon)	184
Graphidox (50% silicon)	46

Casting Composition

	Actual Ladle Analysis (%)
Total carbon	3.02
Manganese	0.78
Silicon	1.82
Phosphorus	0.067
Sulfur	0.055
Chromium	0.03
Nickel	0.11
Molgbdenum	0.28
Copper	0.669

Examination of Cleaned Casting

I examined the casting on May 14, 1984, immediately after shotblast cleaning but before painting (and before shop inspection by Delaval) with the objective of locating and identifying any defects, especially those which would be harmful to the casting's integrity and intended service as an engine block.

My examination was visual, aided by a B&L 5x hand magnifying glass, measuring tape and scale, supplementary lights, and a Newage pin brinell portable metal hardness tester. (The purpose of the hardness tester was not to determine definitive hardness levels, but simply to compare hardness levels at several points on the casting and to help detect possible porosity or other casting inhomogeneities.)

The casting was set up on rails and blocks in a well-lighted area so that I was able to examine every surface, interior and exterior, cope and drag sides, as well as core cavities. It was blown free of metal blasting shot for my inspection. Particular attention was given to the head surfaces and each cylinder bore area.

The casting was examined from the viewpoints and the system of organization described in The International Atlas of Casting Defects, publ. 1974 by The American Foundrymen's Society, Des Plaines, Illinois; and the Analysis of Casting Defects, 4th ed., 1st revision, publ. 1974 by the American Foundrymen's Society, Des Plaines, Illinois.

CONCLUSIONS - EXAMINATION OF THE CASTING

1. Metallic Projections

I saw no evidence of thick fins or veins, swells, nor any significant washes, crushes, drops, raises or scabs. Thin fins and thin veins in fillet areas had been carefully ground clean. One minor veined area (1-inch long, thin vein) was noticed in a cored slot on the water jacket side, and some minor veining in an outside flange-sidewall fillet.

2. Cavities

I saw no evidence of surface or corner blowholes or pinholes, nor any shrinks or draws. The casting appears sound.

3. Discontinuities

Careful inspection revealed no cold or hot cracks or tears, nor any cold shuts visible to my naked eye, nor under the 5x glass I used. Special attention was paid to internal fillets such as in the camshaft bearing saddle areas.

4. Surface Irregularities

There are no folds, seams, roughness, buckles, rat-tails, orange peel, slag inclusions, sinks or draws, or clamp-off defects, and no significant crushes, burn-ons or burn-ins, metal penetration or scabs were visible. Very minor burn-ons or metal penetration had been carefully ground clean. One small surface irregularity, 2 inches long by 1/2 inch wide and

1/2 inch deep, in a cope side pocket fillet area near the #4 cylinder liner support ring, water jacket side, I judge insignificant.

5. Incompleteness

There is no sign of misrun, short pour, or runout in this casting, nor should there be, based on my observation of the molten iron temperature and casting sequence on May 2. Gates to the lower block flange (cope side of the casting as poured) measure approximately 3-1/2 inches wide by 2-1/2 inches high. One of these gates, between the #2 and #4 cylinders, camshaft side, suffered a break-in when the gating and risering system was removed. This break-in is between the flange bolt hole locations and in front of a major reinforcing member. It does not extend to the flat sealing surface of the flange; machining stock to be removed will help minimize the significance of this break-in. No cracks or incipient cracks were visible in or radiating from this break-in area.

A second small (2 inches long by 1/2 inch deep) gate break-in exists in the flange below #8 cylinder; this will probably be removed during machining, and I judge it to be insignificant.

No break-in or porosity was visible at the test bar ingate areas, which are located inside the cores in the approximate center of the casting.

6. Incorrect Dimensions

I saw no evidence of casting deformation, mold or core

shift, or ram-off defects in this casting.

7. <u>Inclusions</u>

I saw no metallic inclusions, cold shot, slag, dross, sand, refractory, oxide or graphite flotation defects.

Hardness Tests

In a test for any major unsoundness or inhomogeneities in the casting, I made several hardness measurements using a Newage pin brinell hardness tester. Because the surfaces tested were shot-blasted but not ground, the impression readings are not meant to be a measure of actual brinell hardness level. A properly prepared surface would yield higher values.

The pin indentation diameters that were measured indicated good homogeneity. The heaviest sections, which cooled slowest, showed somewhat greater indentation diameters than the flange, which cooled faster and would be expected to be harder. There was no indication of micro- or gross shrinkage from these observations.

Location	Indentation Diameter (average reading) in millimeters
Flange-Drag side-near ingate break-in area	2.90 - Test 1 2.75 - Test 2
Head surface - between #4 and #5 cylinders	3.20
Head surface, beyond #1 cylinder	3.10
Head surface, outside #5 cylinder	2.90 - Test 1 3.00 - Test 2
Head surface, between #7 and #8 cylinders	3.00

Except for the flange break-in mentioned in Conclusion 5, the casting as judged by my visual inspection is of excellent quality.