

THERMOMECHANICAL MEASUREMENTS FOR ENERGY SYSTEMS

MENR (A.A. 2017-2018)

Laboratory n. 6

Two thermal reference points at 0°C (melted ice) and at 100° (boiled water) are available.

There are three electrical thermometers (RTD, thermistor, Cromel-Alumel thermocouple).

1. Define the accuracy of the RTD measurement when measuring the reference temperatures. Explain why, in this case, a 4 wire volt-ampere circuit is used to convert resistance to voltage.
2. Define the coefficient β that compares in the thermistor's graduation curve and calculate the thermistor sensitivity at 0°C and at 100°C.
3. Measure the unknown temperature of the water in a vessel with the thermocouple thermometer, first with cold junction at 0°C and then at 100°C.
4. Do the same measurement of point 3 with the infrared thermal camera (FLIR E50).

**Thermocouple Cromel-Alumel
Cold Junction at 0°C**

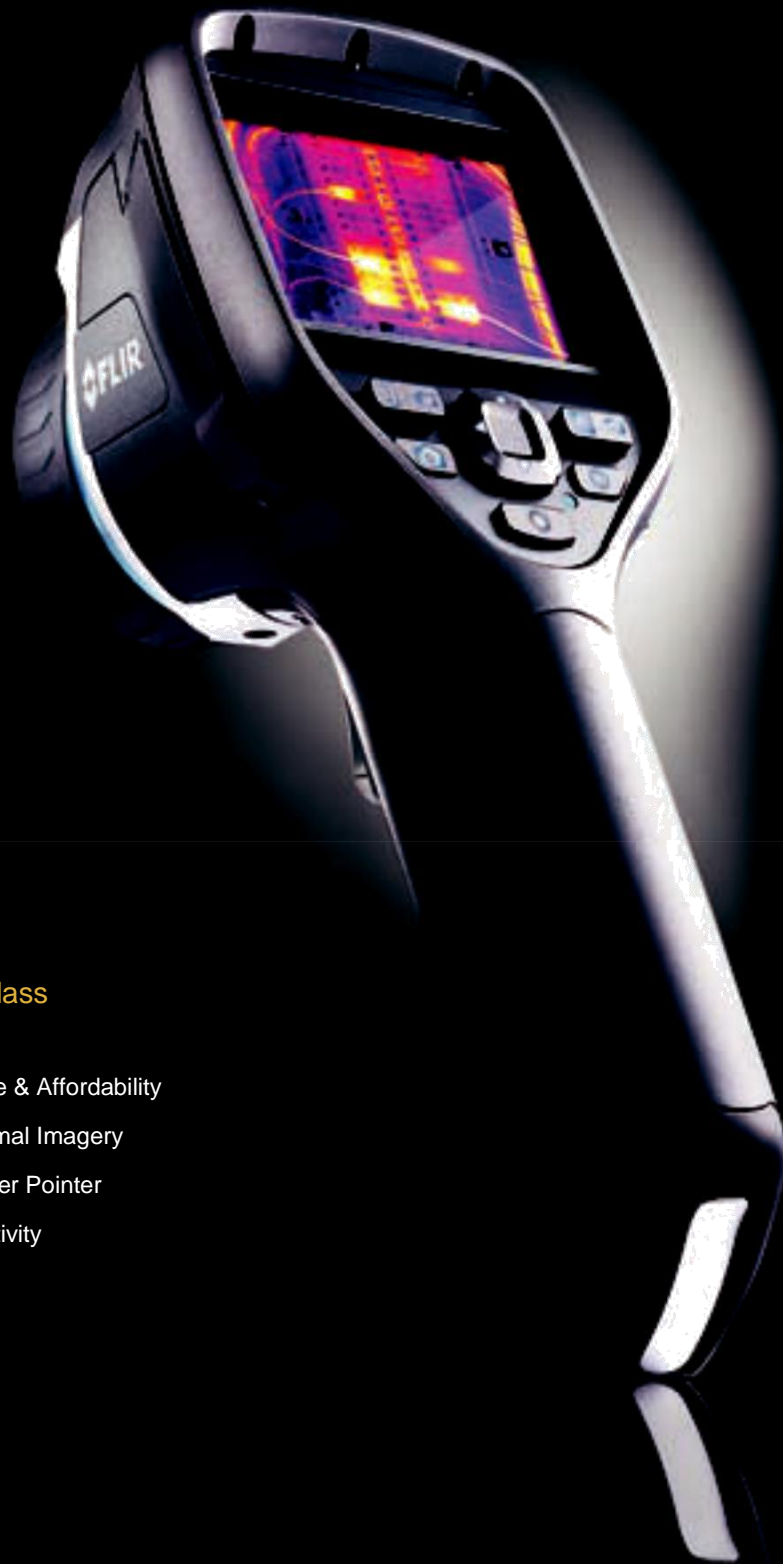
| Sensor (°C) | Output (mV) | Sensor (°C) | Output (mV) |
|-------------|-------------|-------------|-------------|
| 0 | 0,00 | 52 | 2,10 |
| 2 | 0,03 | 54 | 2,18 |
| 4 | 0,16 | 56 | 2,26 |
| 6 | 0,24 | 58 | 2,34 |
| 8 | 0,32 | 60 | 2,43 |
| 10 | 0,40 | 62 | 2,51 |
| 12 | 0,48 | 64 | 2,59 |
| 14 | 0,56 | 66 | 2,67 |
| 16 | 0,64 | 68 | 2,76 |
| 18 | 0,72 | 70 | 2,85 |
| 20 | 0,80 | 72 | 2,93 |
| 22 | 0,88 | 74 | 3,01 |
| 24 | 0,96 | 76 | 3,09 |
| 26 | 1,04 | 78 | 3,17 |
| 28 | 1,12 | 80 | 3,26 |
| 30 | 1,20 | 82 | 3,34 |
| 32 | 1,28 | 84 | 3,42 |
| 34 | 1,36 | 86 | 3,50 |
| 36 | 1,44 | 88 | 3,59 |
| 38 | 1,52 | 90 | 3,68 |
| 40 | 1,61 | 92 | 3,76 |
| 42 | 1,69 | 94 | 3,84 |
| 44 | 1,77 | 96 | 3,92 |
| 46 | 1,85 | 98 | 4,01 |
| 48 | 1,93 | 100 | 4,10 |
| 50 | 2,02 | | |

**RTD
Pt 100**

| Sensor (°C) | Output |
|-------------|--------|
| -200 | 18,49 |
| -100 | 60,25 |
| 0 | 100,00 |
| 10 | 103,90 |
| 20 | 107,79 |
| 30 | 111,67 |
| 40 | 115,54 |
| 50 | 119,40 |
| 60 | 123,24 |
| 70 | 127,07 |
| 80 | 130,89 |
| 90 | 134,70 |
| 100 | 138,50 |
| 200 | 175,84 |
| 300 | 212,02 |
| 400 | 247,04 |
| 500 | 280,90 |
| 600 | 313,59 |
| 700 | 345,13 |
| 800 | 375,51 |

| Range (°C) | Sensitivity (mV/°C) |
|------------|---------------------|
| 0 -100 | 0,0410 |
| 100-200 | 0,0403 |
| 200-300 | 0,0408 |
| 300-400 | 0,0418 |
| 400-500 | 0,0425 |
| 500-600 | 0,0426 |
| 600-700 | 0,0424 |
| 700-800 | 0,0417 |
| 800-900 | 0,0405 |
| 900-1000 | 0,0395 |
| 1000-1100 | 0,0383 |
| 1100-1200 | 0,0371 |
| 1200-1300 | 0,0356 |
| 1300-1400 | 0,0340 |

FLIR E-Series Thermal Imaging Cameras



E-Series

A Brand New Line

Now the Leader in its Class

Groundbreaking Performance & Affordability

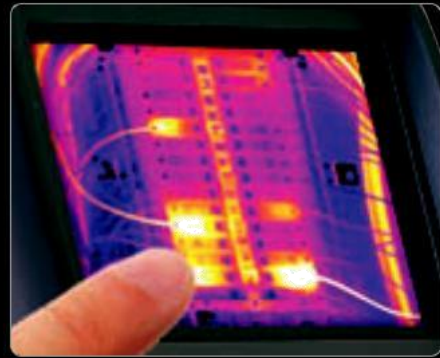
Superior Point & Shoot Thermal Imagery

Built-in Digital Camera & Laser Pointer

Mobile Device Wi-Fi Connectivity

Large Bright Touchscreen

The E-Series



Large 3.5" Touchscreen Puts Fast Tools at Your Fingertips



Visible Light Pictures Align with Thermal Images

- 3 MP Digital Camera
- LED Lamp
- Laser Pointer



Connect to iPhone or iPad via Wi-Fi to Use the FLIR Viewer App for Processing and Sharing Results



Large Backlit Buttons Fit Bare Hands or Gloves

E-Series Features

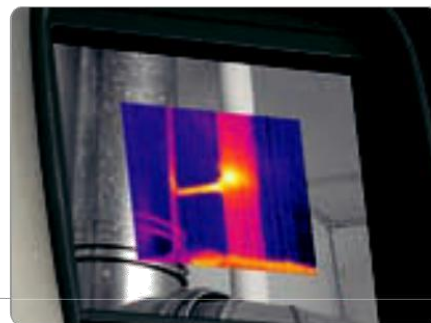
Presenting the best performance and value in compact thermal imaging cameras ever, designed to fit beautifully into your IR inspection program, budget, and the palm of your hand.



Spot LED Light for Dark Corners



Add Up to 3 Moveable Measurement Spots Easily



Picture-in Picture Display

Superior Thermal Imaging – Up to 76,800 pixels (320 x 240) for better long-range accuracy and the highest level of point & shoot camera IR resolution

Improved Digital Camera – 3 megapixel resolution provides clearest visible light pictures in its class and includes bright LED lamp that doubles as a flashlight

New! Large Landscape Touchscreen – Brighter than other brands, the E-Series touchscreen provides an intuitive interface that takes full advantage of the entire 3.5" display with no image cropping

New! Wi-Fi Connectivity – Send images and data to an iPhone® or iPad® to share reports and critical information quickly using FLIR View App

Laser Pointer – Pinpoints a reference spot with a laser and aligns a marker to it on the image for precise detection

Accurate Temperature Measurements – Accuracy calibrated within 2% or +/- 2°C to meet the standard you can always trust FLIR to deliver

Scalable P-i-P and Thermal Fusion – Overlay thermal and visible images for easy location identification and clearer documentation

Multiple Measurements – Add up to 3 box areas and 3 moveable spots using the touchscreen to gather more detailed temperature information

MeterLink – Wirelessly transmit vital diagnostic data from clamp and moisture meters directly to the camera for annotating thermal images to further support findings and decisions

Annotation – Add voice comments via Bluetooth headset and text notes from the touchscreen keypad

InstantReport – Generate a professional PDF document directly from the camera right on site

Plenty of Extras – Small, light, and rugged with large, backlit, easy-to-operate buttons, 6 palette choices, and more

A New Choice in Compact Thermal Imaging

- **E30** – 19,200 pixels *Optimal and efficient*
- **E40** – 19,200 pixels *Wi-Fi to mobile devices & higher sensitivity*
- **E50** – 43,200 pixels *Superior accuracy and sensitivity*
- **E60** – 76,800 pixels *Best point & shoot thermal resolution*

E30

Includes:

- High quality thermal imaging at 19,200 pixels (160 x 120)
- Thermal sensitivity of 0.10°C
- 3.5" touch-screen LCD
- Manual focus
- 60 Hz image frequency
- Auto/manual level span adjustments
- Temperature calibration standard at 250°C
- Isotherm and automatic hot/cold detection marker
- Radiometric and non-radiometric IR video streaming
- Laser pointer
- Composite video and USB-mini outputs
- FLIR Tools software for camera updates

E40

Additional Features:

- 3 megapixel digital visible light camera with lamp
- Wi-Fi connectivity to iPad/iPhone FLIR Viewer application
- Thermal sensitivity of 0.07°C
- Picture-in-Picture to superimpose thermal images
- Temperature calibration standard at 650°C
- DeltaT temperature difference function
- 2x digital zoom
- 3 moveable spots and 3 box areas
- Voice & text annotation
- Fixed Picture-in-Picture to overlay thermal & digital images
- MeterLink via Bluetooth to clamp and moisture meters

E50

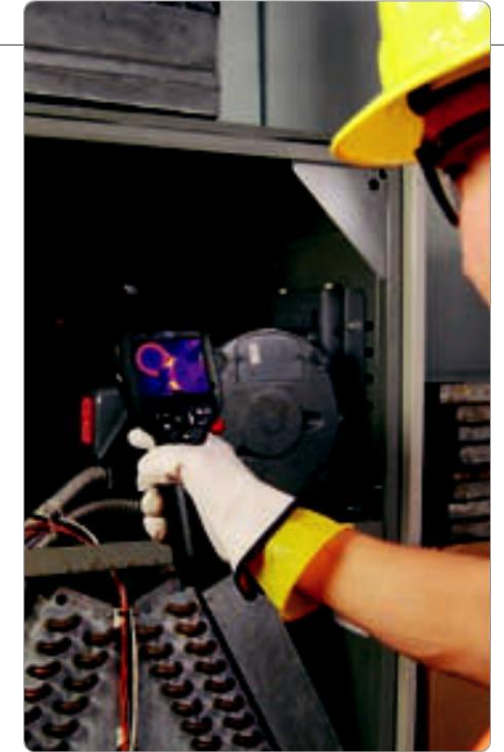
Additional Features:

- Higher quality IR at 43,200 pixel (240 x 180) resolution
- Thermal sensitivity of 0.05°C
- 4x digital zoom
- Thermal fusion to blend IR with visible light images
- Scalable Picture-in-Picture

E60

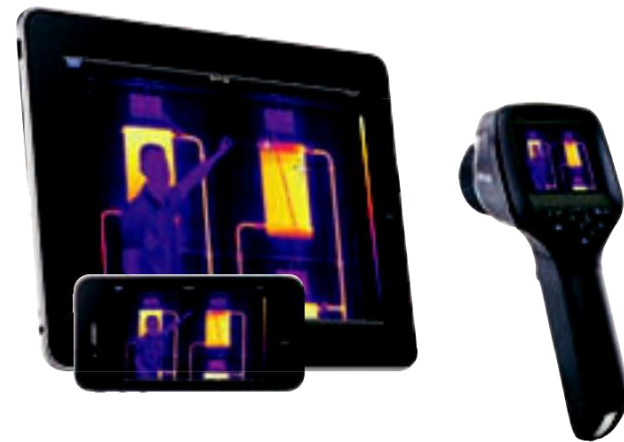
Additional Features:

- Best point & shoot resolution at 76,800 pixels (320 x 240)
- InstantReport



Wi-Fi Connectivity to Mobile Devices

Download the new FLIR Viewer App from the Apple Store to your iPad or iPhone and link to E-Series cameras via Wi-Fi. Transfer images to your mobile device, then use it to add further measurement spots, readjust span and level, change palettes, create reports, and email findings to decision makers easily. It's an efficient way to make a big impact.



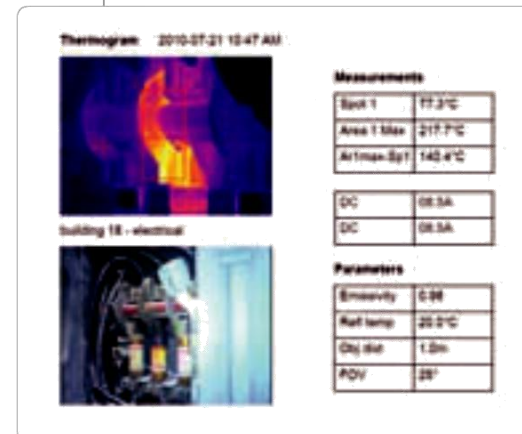
MeterLink™

Be sure you're getting critical electrical load readings so you make the right call. Quantify the severity of electrical problems with MeterLink-enabled clamp meters that use Bluetooth wireless communication to send data to the FLIR camera for annotation on stored thermal images. Contact FLIR to learn about other tools that connect with MeterLink.



InstantReport

Create professional reports on board your camera with InstantReport. FLIR's analysis software has always offered professional results and been easy to use. Now create reports without a PC! InstantReport includes thermal and visual images along with your measurement tools and text & sketch annotations in a standard PDF document that's easy to share right from the touchscreen.



Imaging Specifications



| Model Number | E30 | E40 | E50 | E60 |
|-----------------------------|--|---------------------------------|----------------------------------|----------------------------------|
| Imaging | | | | |
| Resolution | 160 x 120 | 160 x 120 | 240 x 180 | 320 x 240 |
| Total Pixels | 19,200 | 19,200 | 43,200 | 76,800 |
| Thermal Sensitivity | <0.10°C | <0.07°C | <0.05°C | <0.05°C |
| Accuracy | +/-2% or 2°C | | | |
| Temperature Range | -4°F to 482°F (-20°C to 250°C) | 4°F to 1,202°F (-20°C to 650°C) | -4°F to 1,202°F (-20°C to 650°C) | -4°F to 1,202°F (-20°C to 650°C) |
| Lens Options | Standard: 25° x 19° | | | |
| Zoom | | 2x Continuous Digital | 4x Continuous Digital | 4x Continuous Digital |
| Focus | Manual | | | |
| Uncooled Microbolometer | x | x | x | x |
| Color LCD Touch Screen | 3.5" (320 x 240) | | | |
| 3 MP Video Camera w/Lamp | | x | x | x |
| Picture-in-Picture | | Fixed | Scalable | Scalable |
| Fusion | | | x | x |
| Laser Spot | x | x | x | x |
| Video Out | Composite | | | |
| Frame Rate | 60 Hz | | | |
| Analysis | | | | |
| Moveable Spots | 1 | 3 | 3 | 3 |
| Box Areas | 1 | 3 | 3 | 3 |
| Delta T | | x | x | x |
| Annotation | | | | |
| Voice | | x | x | x |
| Text | | x | x | x |
| File Storage | | | | |
| Radiometric JPG to SD Card | x | x | x | x |
| MPEG4 Video Recording | | x | x | x |
| Other | | | | |
| Wi-Fi to iPhone/iPad | | x | x | x |
| MPEG4 Streaming Video Wi-Fi | x | x | x | x |
| Bluetooth to PC/Smartphone | | x | x | x |
| MeterLink | | x | x | x |
| InstantReport | | | | x |
| FLIR Tools | x | x | x | x |
| Battery Type/Op Time | Li-Ion/4 hours | | | |
| Weight | TBD | | | |
| Warranty | 2 Years (warranty extended to 2 years when camera is registered) | | | |

‡ Professional analytics tools include DeltaT functionality and multiple movable spots



10 - Year Detector Protection
 5 - Year Battery
 2 - Year Parts & Labor

Infrared Training Center

Get the most out of your FLIR investment and advance your career with world-class instruction through the Infrared Training Center. An ITC certificate is written proof of your expertise in operating your camera and interpreting the thermal information it provides.

For full course descriptions, updated schedules, and more information, visit www.infraredtraining.com or call 1.866.872.4847.

