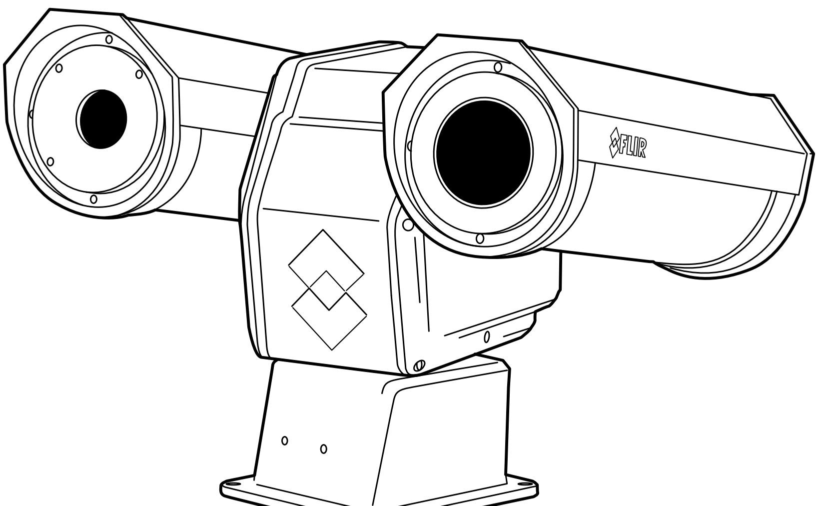
User’s manual
FLIR G300 pt



User's manual
FLIR G300 pt

Intertek

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1 Legal disclaimer

1.1 Legal disclaimer

All products manufactured by FLIR Systems are warranted against defective materials and workmanship for a period of one (1) year from the delivery date of the original purchase, provided such products have been under normal storage, use and service, and in accordance with FLIR Systems instruction.

Uncooled handheld infrared cameras manufactured by FLIR Systems are warranted against defective materials and workmanship for a period of two (2) years from the delivery date of the original purchase, provided such products have been under normal storage, use and service, and in accordance with FLIR Systems instruction, and provided that the camera has been registered within 60 days of original purchase.

Detectors for uncooled handheld infrared cameras manufactured by FLIR Systems are warranted against defective materials and workmanship for a period of ten (10) years from the delivery date of the original purchase, provided such products have been under normal storage, use and service, and in accordance with FLIR Systems instruction, and provided that the camera has been registered within 60 days of original purchase.

Products which are not manufactured by FLIR Systems but included in systems delivered by FLIR Systems to the original purchaser, carry the warranty, if any, of the particular supplier only. FLIR Systems has no responsibility whatsoever for such products.

The warranty extends only to the original purchaser and is not transferable. It is not applicable to any product which has been subjected to misuse, neglect, accident or abnormal conditions of operation. Expendable parts are excluded from the warranty.

In the case of a defect in a product covered by this warranty the product must not be further used in order to prevent additional damage. The purchaser shall promptly report any defect to FLIR Systems or this warranty will not apply.

FLIR Systems will, at its option, repair or replace any such defective product free of charge if, upon inspection, it proves to be defective in material or workmanship and provided that it is returned to FLIR Systems within the said one-year period.

FLIR Systems has no other obligation or liability for defects than those set forth above.

No other warranty is expressed or implied. FLIR Systems specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

FLIR Systems shall not be liable for any direct, indirect, special, incidental or consequential loss or damage, whether based on contract, tort or any other legal theory.

This warranty shall be governed by Swedish law.

Any dispute, controversy or claim arising out of or in connection with this warranty, shall be finally settled by arbitration in accordance with the Rules of the Arbitration Institute of the Stockholm Chamber of Commerce. The place of arbitration shall be Stockholm. The language to be used in the arbitral proceedings shall be English.

1.2 Usage statistics

FLIR Systems reserves the right to gather anonymous usage statistics to help maintain and improve the quality of our software and services.

1.3 Changes to registry

The registry entry HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Lsa\LmCompatibilityLevel will be automatically changed to level 2 if the FLIR Camera Monitor service detects a FLIR camera connected to the computer with a USB cable. The modification will only be executed if the camera device implements a remote network service that supports network logons.

1.4 U.S. Government Regulations

This product may be subject to U.S. Export Regulations. Please send any inquiries to exportquestions@flir.com.

1.5 Copyright

1.6 Quality assurance

The Quality Management System under which these products are developed and manufactured has been certified in accordance with the ISO 9001 standard.

FLIR Systems is committed to a policy of continuous development; therefore we reserve the right to make changes and improvements on any of the products without prior notice.

1.7 Patents

One or several of the following patents and/or design patents may apply to the products and/or features. Additional pending patents and/or pending design patents may also apply.

000279476-0001; 000439161; 000499579-0001; 000653423; 000726344; 000859020; 001106306-0001; 001707738; 001707746; 001707787; 001776519; 001954074; 002021543; 002058180; 002249953; 002531178; 0600574-8; 1144833; 1182246; 1182620; 1285345; 1299699; 1325808; 1336775; 1391114; 1402918; 1404291; 1411581; 1415075; 1421497; 1458284; 1678485; 1732314; 2106017; 2107799; 2381417; 3006596; 3006597; 466540; 483782; 484155; 4889913; 5177595; 60122153.2; 602004011681.5-08; 6707044; 68657; 7034300; 7110035; 7154093; 7157705; 7237946; 7312822; 7332716; 7336823; 7544944; 7667198; 7809258 B2; 7826736; 8,153,971; 8,823,803; 8,853,631; 8018649 B2; 8212210 B2; 8289372; 8354639 B2; 8384783; 8520970; 8565547; 8595689; 8599262; 8654239; 8680468; 8803093; D540838; D549758; D579475; D584755; D599,392; D615,113; D664,580; D664,581; D665,004; D665,440; D677298; D710,424 S; D718801; DI6702302-9; DI6903617-9; DI7002221-6; DI7002891-5; DI7002892-3; DI7005799-0; DM/057692; DM/061609; EP 2115696 B1; EP2315433; SE 0700240-5; US 8340414 B2; ZL 201330267619.5; ZL01823221.3; ZL01823226.4; ZL02331553.9; ZL02331554.7; ZL200480034894.0; ZL200530120994.2; ZL200610088759.5; ZL200630130114.4; ZL200730151141.4; ZL200730339504.7; ZL200820105768.8; ZL200830128581.2; ZL200880105236.4; ZL200880105769.2; ZL200930190061.9; ZL201030176127.1; ZL201030176130.3; ZL201030176157.2; ZL201030595931.3; ZL201130442354.9; ZL201230471744.3; ZL201230620731.8.

1.8 EULA Terms

- You have acquired a device (“INFRARED CAMERA”) that includes software licensed by FLIR Systems AB from Microsoft Licensing, GP or its affiliates (“MS”). Those installed software products of MS origin, as well as associated media, printed materials, and “online” or electronic documentation (“SOFTWARE”) are protected by international intellectual property laws and treaties. The SOFTWARE is licensed, not sold. All rights reserved.
- IF YOU DO NOT AGREE TO THIS END USER LICENSE AGREEMENT (“EULA”), DO NOT USE THE DEVICE OR COPY THE SOFTWARE. INSTEAD, PROMPTLY CONTACT FLIR Systems AB FOR INSTRUCTIONS ON RETURN OF THE UNUSED DEVICE(S) FOR A REFUND. **ANY USE OF THE SOFTWARE, INCLUDING BUT NOT LIMITED TO USE ON THE DEVICE, WILL CONSTITUTE YOUR AGREEMENT TO THIS EULA (OR RATIFICATION OF ANY PREVIOUS CONSENT).**
- **GRANT OF SOFTWARE LICENSE.** This EULA grants you the following license:
  - You may use the SOFTWARE only on the DEVICE.
  - **NOT FAULT TOLERANT.** THE SOFTWARE IS NOT FAULT TOLERANT. FLIR Systems AB HAS INDEPENDENTLY DETERMINED HOW TO USE THE SOFTWARE IN THE DEVICE, AND MS HAS RELIED UPON FLIR Systems AB TO CONDUCT SUFFICIENT TESTING TO DETERMINE THAT THE SOFTWARE IS SUITABLE FOR SUCH USE.
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  - **Limitations on Reverse Engineering, Decompilation, and Disassembly.** You may not reverse engineer, decompile, or disassemble the SOFTWARE, except and only to the extent that such activity is expressly permitted by applicable law notwithstanding this limitation.
  - **SOFTWARE TRANSFER ALLOWED BUT WITH RESTRICTIONS.** You may permanently transfer rights under this EULA only as part of a permanent sale or transfer of the Device, and only if the recipient agrees to this EULA. If the SOFTWARE is an upgrade, any transfer must also include all prior versions of the SOFTWARE.
  - **EXPORT RESTRICTIONS.** You acknowledge that SOFTWARE is subject to U.S. export jurisdiction. You agree to comply with all applicable international and national laws that apply to the SOFTWARE, including the U.S. Export Administration Regulations, as well as end-user, end-use and destination restrictions issued by U.S. and other governments. For additional information see http://www.microsoft.com/exporting/.

2 Safety information

DANGER

Applicability: FLIR A3xx pt & G300 pt.

Do not install the unit in lightning weather. A lightning strike can hit the unit and cause injury or death.

DANGER

Applicability: FLIR A3xx pt & G300 pt.

Be careful when you install or do an inspection of the unit at high heights. The unit can move suddenly and this can cause you to fall. This can cause injury or death.

DANGER

Applicability: FLIR A3xx pt & G300 pt.

Make sure that you use the industry standard safety procedures when you install or do an inspection of the unit at high heights. If you do not use the industry standard safety procedures, this can cause you to fall. This can cause injury or death.

WARNING

Make sure that you read all applicable MSDS (Material Safety Data Sheets) and warning labels on containers before you use a liquid. The liquids can be dangerous. Injury to persons can occur.

WARNING

Applicability: FLIR A3xx pt & G300 pt.

Be careful when you lift the unit when it is not energized. This can cause the parts of the unit to move freely and cause injury.

WARNING

Applicability: FLIR A3xx pt & G300 pt.

Do not go near the unit when it is energized. The unit can move suddenly and cause injury.

WARNING

Applicability: FLIR A3xx pt & G300 pt.

Do not go near the unit during the startup. The unit can move suddenly and cause injury.

WARNING

Applicability: FLIR A3xx pt & G300 pt.

A minimum of two persons are necessary to lift the unit. The unit can cause injury when the center of gravity moves.

WARNING

Applicability: FLIR A3xx pt & G300 pt.

Make sure that you install the unit safely. If you do not install it safely, the unit can fall down and cause injury.

WARNING

Applicability: FLIR A3xx pt & G300 pt.

If the IR or the TV window breaks, do not touch the broken pieces. The pieces can cause injury.

WARNING

Applicability: FLIR A3xx pt & G300 pt.

Be careful when you touch the unit. Some parts can be sharp and cause injury.

CAUTION

Do not point the infrared camera (with or without the lens cover) at strong energy sources, for example, devices that cause laser radiation, or the sun. This can have an unwanted effect on the accuracy of the camera. It can also cause damage to the detector in the camera.

CAUTION

Do not use the camera in temperatures more than +50°C (+122°F), unless other information is specified in the user documentation or technical data. High temperatures can cause damage to the camera.

CAUTION

Do not apply solvents or equivalent liquids to the camera, the cables, or other items. Damage to the battery and injury to persons can occur.

CAUTION

Be careful when you clean the infrared lens. The lens has an anti-reflective coating which is easily damaged. Damage to the infrared lens can occur.

CAUTION

Do not use too much force to clean the infrared lens. This can cause damage to the anti-reflective coating.

CAUTION

Applicability: Cameras with an automatic shutter that can be disabled.

Do not disable the automatic shutter in the camera for a long time period (a maximum of 30 minutes is typical). If you disable the shutter for a longer time period, damage to the detector can occur.

NOTE

The encapsulation rating is only applicable when all the openings on the camera are sealed with their correct covers, hatches, or caps. This includes the compartments for data storage, batteries, and connectors.

CAUTION

Applicability: Cameras where you can remove the lens and expose the infrared detector.

Do not use the pressurized air from the pneumatic air systems in a workshop when you remove dust from the detector. The air contains oil mist to lubricate the pneumatic tools and the pressure is too high. Damage to the detector can occur.

3 Notice to user

3.1 User-to-user forums

Exchange ideas, problems, and infrared solutions with fellow thermographers around the world in our user-to-user forums. To go to the forums, visit:

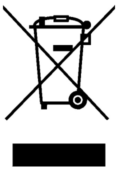
http://www.infraredtraining.com/community/boards/

3.2 Accuracy

For very accurate results, we recommend that you wait 5 minutes after you have started the camera before measuring a temperature.

For cameras where the detector is cooled by a mechanical cooler, this time period excludes the time it takes to cool down the detector.

3.3 Disposal of electronic waste



As with most electronic products, this equipment must be disposed of in an environmentally friendly way, and in accordance with existing regulations for electronic waste.

Please contact your FLIR Systems representative for more details.

3.4 Training

To read about infrared training, visit:

- http://www.infraredtraining.com
- http://www.irtraining.com
- http://www.irtraining.eu

3.5 Documentation updates

Our manuals are updated several times per year, and we also issue product-critical notifications of changes on a regular basis.

To access the latest manuals and notifications, go to the Download tab at:

http://support.flir.com

It only takes a few minutes to register online. In the download area you will also find the latest releases of manuals for our other products, as well as manuals for our historical and obsolete products.

3.6 Important note about this manual

FLIR Systems issues generic manuals that cover several cameras within a model line.

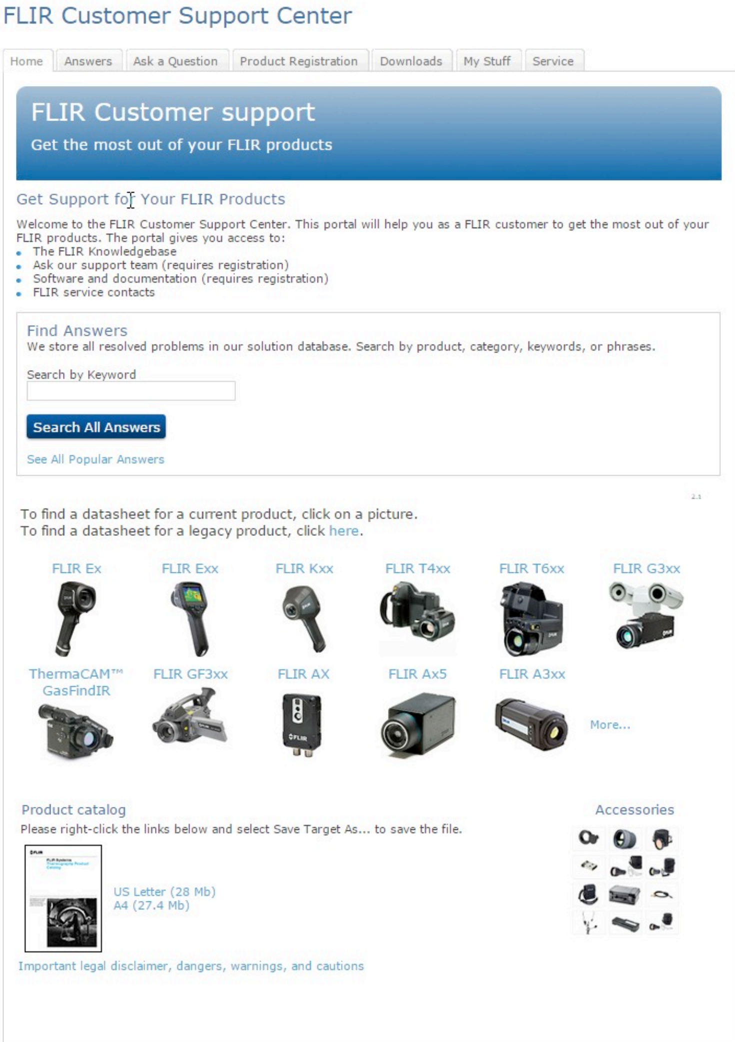
This means that this manual may contain descriptions and explanations that do not apply to your particular camera model.

3.7 Note about authoritative versions

The authoritative version of this publication is English. In the event of divergences due to translation errors, the English text has precedence.

Any late changes are first implemented in English.

4 Customer help



4.1 General

For customer help, visit:

http://support.flir.com

4.2 Submitting a question

To submit a question to the customer help team, you must be a registered user. It only takes a few minutes to register online. If you only want to search the knowledgebase for existing questions and answers, you do not need to be a registered user.

When you want to submit a question, make sure that you have the following information to hand:

- The camera model
- The camera serial number
- The communication protocol, or method, between the camera and your device (for example, HDMI, Ethernet, USB, or FireWire)
- Device type (PC/Mac/iPhone/iPad/Android device, etc.)
- Version of any programs from FLIR Systems
- Full name, publication number, and revision number of the manual

4.3 Downloads

On the customer help site you can also download the following, when applicable for the product:

- Firmware updates for your infrared camera.
- Program updates for your PC/Mac software.
- Freeware and evaluation versions of PC/Mac software.
- User documentation for current, obsolete, and historical products.
- Mechanical drawings (in *.dxf and *.pdf format).
- Cad data models (in *.stp format).
- Application stories.
- Technical datasheets.
- Product catalogs.

5 Important note about training and applications

5.1 General

Infrared inspection of gas leaks, furnaces, and high-temperature applications—including infrared image and other data acquisition, analysis, diagnosis, prognosis, and reporting—is a highly advanced skill. It requires professional knowledge of thermography and its applications, and is, in some countries, subject to certification and legislation.

Consequently, we strongly recommend that you seek the necessary training before carrying out inspections. Please visit the following site for more information:

http://www.infraredtraining.com

6 Introduction

The new FLIR G300 pt is a ground-breaking optical gas imaging system capable of continuously monitoring vast areas for greenhouse gas emissions or volatile organic compounds (VOCs). The system is also perfect for monitoring a pinpointed area over a long period of time, making around-the-clock monitoring possible.

The precision pan/tilt mechanism gives the operator accurate pointing control, and the environmental housing is built to withstand tough weather conditions. The FLIR G300 pt can pan ±360° continuously and tilt ±45°. It is ideal for covering large areas. The FLIR G300 pt is a multi-sensor system and includes a gas-imaging camera (FLIR G300 a) that visualizes greenhouse gas emissions or VOCs as well as a low-light 36× zoom color CCD camera.

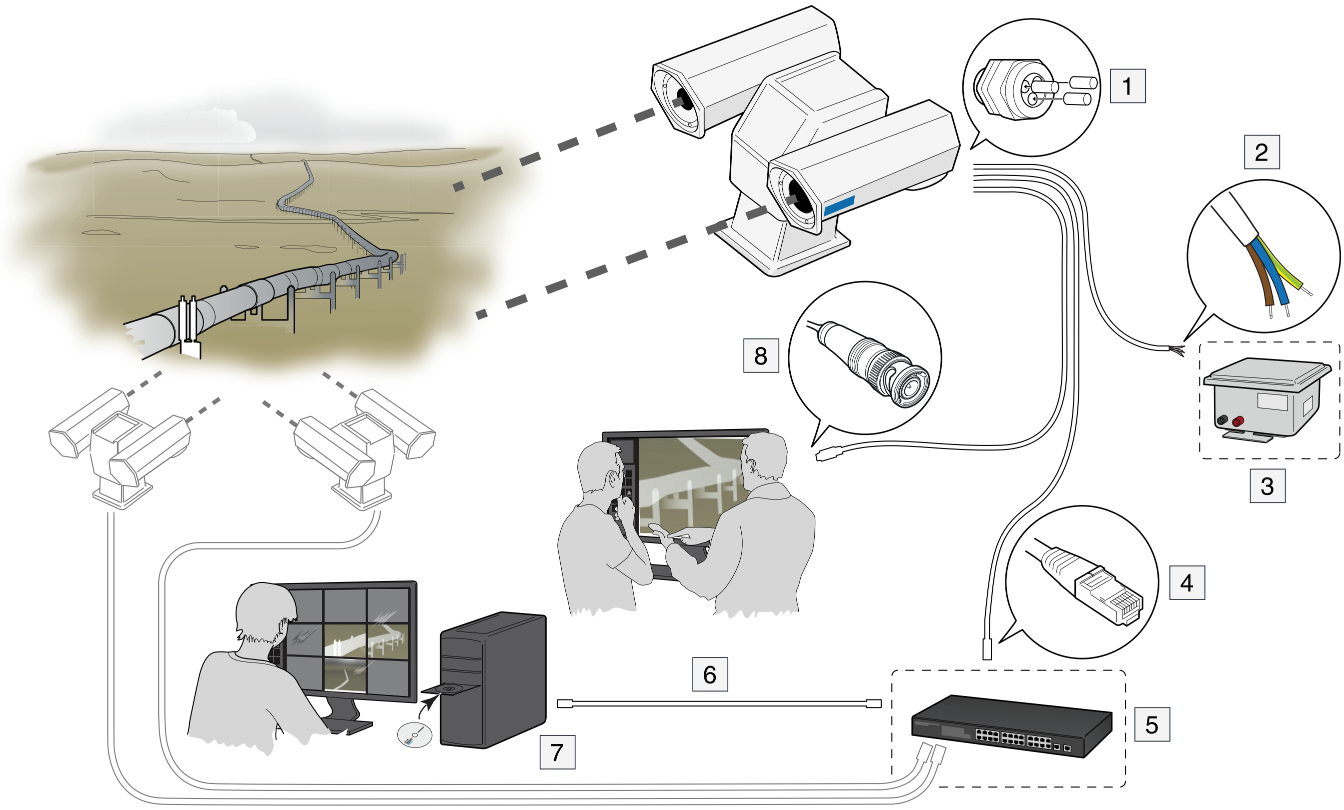
Key features:

- Visualizes gas leaks in real time.
- Scans vast or pinpointed areas continuously.
- Remote control.
- Precise pan/tilt camera.
- Inspects without interruption.
- Traces leaks to their source.
- IP66 protection.

The FLIR G300 pt detects the following gases:

- 1-pentene
- benzene
- butane
- ethane
- ethanol
- ethylbenzene
- ethylene
- heptane
- hexane
- isoprene
- *m*-xylene
- methane
- methanol
- methyl ethyl ketone (MEK)
- methyl isobutyl ketone (MIBK)
- octane
- pentane
- propane
- propylene.
- toluene

7 Typical system overview



7.1 Explanation

1. Cable gland.
2. Pigtail cable from the housing:
   - Brown: positive (+).
   - Blue: negative (–).
   - Green/yellow: earth.
3. 21–30 V AC/DC power supply.
4. Ethernet cable with an RJ45 connector.
5. Ethernet switch.
6. Ethernet cable with an RJ45 connector.
7. PC with ThermoVision System Tools & Utilities software.
8. Video cable with a BNC connector.

8 Quick start guide

Follow this procedure:

1. Connect the power and video cables to the camera.

⚠ WARNING
Do not go near the unit when it is powered. The unit can move suddenly and cause injury.

2. Connect the video cable from the camera to a display/monitor, and connect the power cable to a power supply. The camera operates on 24 VAC (21-30 VAC; 24 VAC: 215 VA max. with heater) or 24 VDC (21-30 VDC; 24 VDC: 200 W max. with heater). Verify that video output is displayed on the monitor.
3. As shipped from the factory, the FLIR G300 pt series camera has an IP address of 192.168.250.116 with a netmask of 255.255.255.0. Configure a computer with another IP address from this network (e.g., 192.168.250.xxx).
4. Connect the camera and the computer to the same Ethernet switch (or back to back with an Ethernet crossover cable). In some cases, a straight Ethernet cable can be used because many computers have an auto-detect Ethernet interface.
5. Open a web browser, enter 192.168.250.116 in the address bar, and press Enter. This displays a login screen.
6. Log in using the user name *admin* and the password *fliradmin*.
7. Under *LAN Settings*, you can change the IP communications parameters.

9 Installation

9.1 Installation overview

Figure 9.1 FLIR G300 pt series camera

The FLIR G300 pt series camera is a multi-sensor camera system on a pan/tilt platform. Combinations of an infrared thermal imaging camera and a visible-light video camera are intended for outdoor installations.

The FLIR G300 pt series camera is intended to be mounted on a medium-duty fixed pedestal mount or wall mount commonly used in the CCTV industry. Cables will exit from the back of the camera housing. The mount must support up to 45 lb. (20 kg).

The FLIR G300 pt series camera is both an analog and an IP camera. The video from the camera can be viewed over a traditional analog video network or it can be viewed by streaming it over an IP network using MPEG-4, M-JPEG, and H.264 encoding. Analog video will require a connection to a video monitor or an analog matrix/switch. The IP video will require a connection to an Ethernet network switch, and a computer with the appropriate software for viewing the video stream.

The camera can be controlled through either serial or IP communication.

The camera operates on 24 VAC (21-30 VAC; 24 VAC: 215 VA max. with heater) or 24 VDC (21-30 VDC; 24 VDC: 200 W max. with heater).

In order to access the electrical connections and install the cables, it is necessary to temporarily remove the back cover of the camera housing.

9.2 Installation components

In addition to the items included in the cardboard box, the installer will need to supply the following items:

- Electrical wire, for system power.
- Camera grounding strap.
- Coaxial RG59U video cables (BNC connector at the camera end) for analog video.
- Shielded Category 6 Ethernet cable for control and streaming video over an IP network; and also for software upgrades.
- Optional serial cable for serial communication.
- Miscellaneous electrical hardware, connectors, and tools.

9.3 Location considerations

The camera will require connections for power, communications (IP Ethernet and/or RS-232/RS-422), and video (two video connections may be required for analog video installations).

Note Install all cameras with an easily accessible Ethernet connection, to support future software upgrades.
Ensure that cable lengths do not exceed the referenced standard specifications, and also adhere to all local and Industry standards, codes, and best practises.

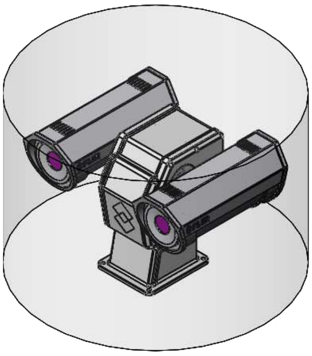


Figure 9.2 FLIR G300 pt series camera exclusion zone. Height 480 mm (18.9″), diameter 740 mm (29.1″).

9.4 Camera mounting

FLIR G300 pt series cameras must be mounted upright on top of the mounting surface, with the base below the camera. The unit should not be hung upside down.

The FLIR G300 pt series camera can be secured to the mount with four 5/16″ or M8 bolts, as shown below.

Note Use washers to protect the painting.

Once the mounting location has been selected, verify that both sides of the mounting surface are accessible.

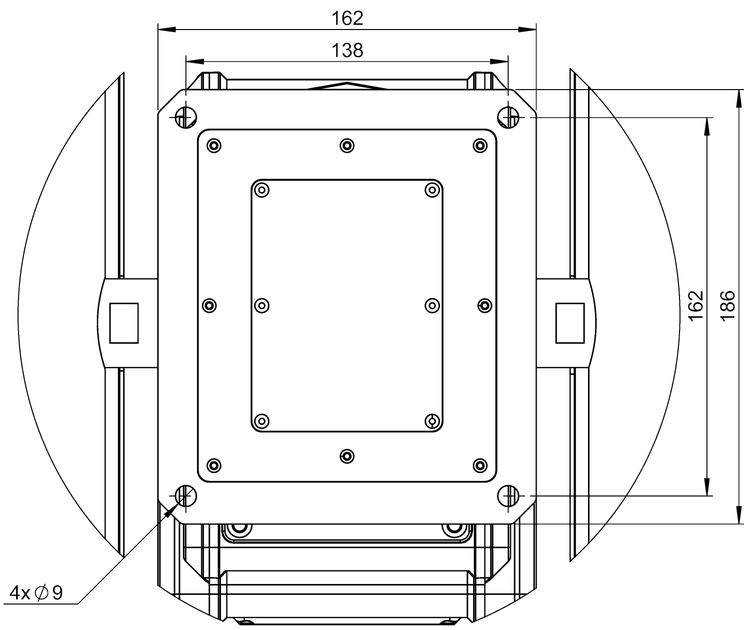


Figure 9.3 FLIR G300 pt series camera mounting (mm)

Connect and operate the camera as a bench test at ground level prior to mounting the camera in its final location.

Use a thread-locking compound such as Loctite 242 or an equivalent with all metal-to-metal threaded connections.

Using the template supplied with the camera as a guide, mark the location of the holes for mounting the camera. If the template is printed, ensure that it is printed to scale so that the dimensions are correct.

Once the holes are drilled in the mounting surface, install four (4) 5/16″ or M8 bolts through the base of the camera.

9.5 Prior to cutting/drilling holes

When selecting a mounting location for the FLIR G300 pt series camera, consider cable lengths and cable routing. Ensure that the cables are long enough given the proposed mounting locations and cable routing requirements.

Use cables that have sufficient dimensions to ensure safety (for power cables) and adequate signal strength (for video and communications).

9.6 Back cover

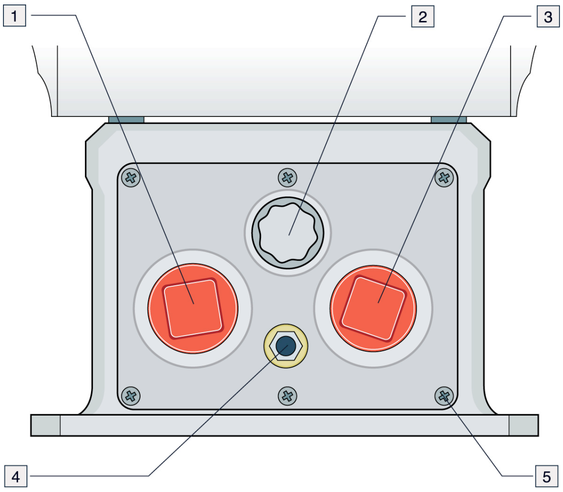


Figure 9.4 Back cover of a FLIR G300 pt series camera.

1. Shipping plug.
2. Breather valve.
3. Shipping plug.
4. Ground lug, for connection to earth.
5. Mounting screw (×6).

The FLIR G300 pt series camera comes with two ¾″ NPT cable glands, each with a three-hole gland seal insert. Cables can be between 0.23″ and 0.29″ OD. Up to six cables may be installed. Plugs are required for the insert hole(s) not being used.

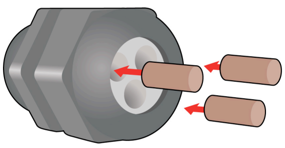


Figure 9.5 ¾″ NPT cable gland.

If non-standard cable diameters are used, you may need to locate or fabricate the appropriate insert to fit the desired cable. FLIR Systems does not provide cable gland inserts other than what is supplied with the system.

Insert the cables through the cable glands on the enclosure before terminating and connecting them. (In general, the terminated connectors will not fit through the cable gland.) If a terminated cable is required, make a single clean cut in the gland seal to install the cable into the gland seal.

Proper installation of cable sealing glands and use of appropriate elastomer inserts is critical to long-term reliability. Cables enter the camera mount enclosure through liquid-tight compression glands. Be sure to insert the cables through the cable glands on the enclosure before terminating and connecting them (the connectors will not fit through the cable gland). Leave the gland nuts loosened until all cable installation has been completed. Inspect and install gland fittings in the back cover with suitable leak sealant, and tighten to ensure water-tight fittings. PTFE tape or pipe sealant (e.g., DuPont RectorSeal T) is suitable for this purpose.

9.7 Removing the back cover

Use a cross-head screwdriver to loosen the four captive screws and remove the cover, exposing the connections at the back of the camera. There is a grounding wire connected between the case and the back cover.

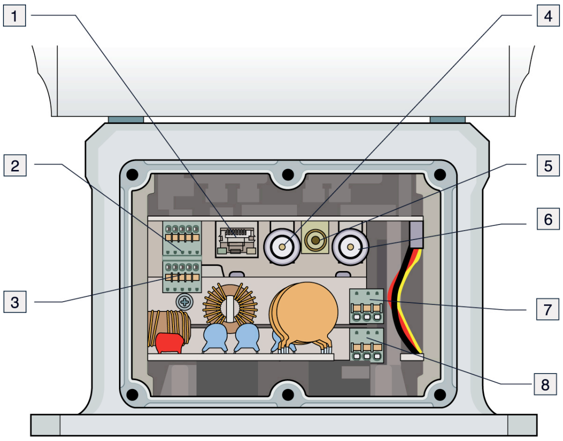


Figure 9.6 Rear view of a FLIR G300 pt series camera, after the back cover has been released.

1. IP network.
2. Not used.
3. Serial connection for local control.
4. Analog infrared video.
5. Analog video (monitoring output only).
6. Analog visual video.
7. Camera power.
8. Heater power.

Note

- Be careful that gaskets are not pinched when mounting the back cover.
- Do not wipe off the grease from the gaskets when mounting the back cover. The grease is critical to the tightness of the housing.

9.8 Connecting power

Power requirements:

24 VAC (21-30 VAC; 24 VAC: 215 VA max. with heater) or 24 VDC (21-30 VDC; 24 VDC: 200 W max. with heater).

The camera itself does not have an on/off switch. Generally, the FLIR G300 pt series camera will be connected to a circuit breaker, and the circuit breaker will be used to connect or interrupt the power supply to the camera. If power is supplied to it, the camera will be in one of two modes: Booting Up or Powered On.

The power cable supplied by the installer must use wires that are of a sufficient gauge size (16 AWG is recommended) for the supply voltage and length of the cable run, to ensure adequate current-carrying capacity. Always follow local building codes.

Ensure the camera is properly grounded. Typical to good grounding practices, the camera chassis ground should be provided using the lowest resistance path possible. FLIR Systems requires using a grounding strap anchored to the grounding lug on the back plate of the camera housing and connected to the nearest earth-grounding point.

Note The terminal blocks for power connections will accept a maximum 16 AWG wire size.

9.9 Video connections

The analog video connections on the back of the camera are BNC connectors.

The video cable used should be rated as RG59U or better to ensure a quality video signal.

9.10 Ethernet connection

The cable gland seal is designed for use with shielded Category 6 Ethernet cable.

9.11 Serial communications overview

The installer must first decide if the serial communications settings will be configured via hardware (DIP switch settings) or software. If the camera has an Ethernet connection, then generally it will be easier (and more convenient in the long run) to make configuration settings via software. Then, configuration changes can be made over the network without physically accessing the camera. Also, the settings can be saved to a file, and backed up or restored as needed.

If the camera is configured via hardware, then configuration changes in the future may require accessing the camera on a tower or pole, dismounting it, removing the back, and so on. If the camera does not have an Ethernet connection, the DIP switches must be used to set the serial communication options.

Note

- The serial communications parameters for the FLIR G300 pt series camera are set or modified either via hardware DIP switch settings or via software, through a web browser interface. A single DIP switch (SW102-9, software override) determines whether the configuration comes from the hardware DIP switches or the software settings.
- The DIP switches are only used to control serial communications parameters. Other settings, related to IP camera functions and so on, must be modified via software (using a web browser).

9.12 Serial connections

For serial communications, it is necessary to set the parameters such as the signalling standard (RS-232 or RS-422), baud rate, number of stop bits, parity, and so on. It is also necessary to select the communication protocol used (either Pelco D or Bosch) and the camera address.

The camera supports RS-422 and RS-232 serial communications using common protocols (Pelco D, Bosch).

Note The terminal blocks for serial connections will accept a maximum 20 AWG wire size.

9.13 Setting configuration dip switches

The figure below shows the locations of dip switches SW102 and SW103.

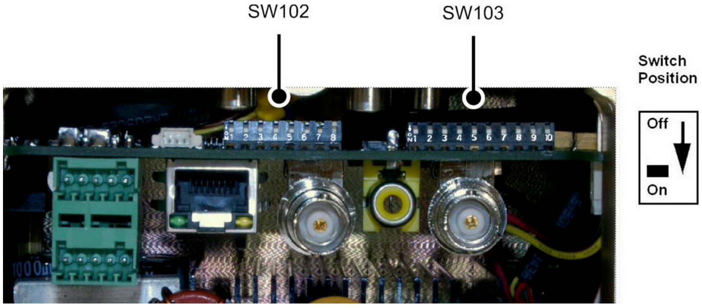


Figure 9.7 Dip switch locations in the FLIR G300 pt series camera.

Pelco Address: This is the address of the system when configured as a Pelco device. The available range of values is from decimal 0 to 255.

Table 9.1 Dip switch address/ID settings—SW102

ID	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
0	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
2	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
3	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
...	...	...	...	...	...	...	...	...
255	ON	ON	ON	ON	ON	ON	ON	ON

Other serial communication parameters: The tables below defines the switch locations, bit numbering, and on/off settings.

Table 9.2 Dip switch address/ID settings—SW103

	Settings		**Descrip-tion**
Baud rate: This is the baud rate of the system user serial port. The available values are 2400, 4800, 9600, 19200 kbaud.	**Bit 1**	**Bit 2**	
	OFF	OFF	2400
	ON	OFF	4800
	OFF	ON	9600
	ON	ON	19200
Camera control protocol: This is the communication protocol selected for the system when operating over the serial port. The available protocols are Pelco-D and Bosch.	**Bit 3**	**Bit 4**	
	OFF	OFF	Pelco-D
	ON	OFF	N/A
	OFF	ON	Bosch
	ON	ON	N/A
Serial communication protocol: This determines the electrical interface selected for the user serial port. The available settings are RS-422 and RS-232.	**Bit 5**	**Bit 6**	
	OFF	OFF	N/A
	ON	OFF	RS-422
	OFF	ON	RS-232
	ON	ON	N/A
Not used.	**Bit 7**	**Bit 8**	
	X	X	
	X	X	
	X	X	
	X	X	
Software override DIP switch: This setting determines whether the system will use software settings for configuration or if the dip switch settings will override the software settings. The default is Off.	**Bit 9**		
	OFF		Software select
	ON		Hardware select
Not used.	**Bit 10**		
	X		

10 Verifying camera operation

Prior to installing the camera, use a bench test to verify camera operation and to configure the camera for the local network. The camera can be controlled through either serial or IP communications.

10.1 Power and analog video

Follow this procedure:

1. Connect the power, video, and serial cables to the camera.
2. Connect the video cable from the camera to a display/monitor, and connect the power cable to a power supply. The camera operates on 24 VAC (21-30 VAC; 24 VAC: 215 VA max. with heater) or 24 VDC (21-30 VDC; 24 VDC: 200 W max. with heater). Verify that video is displayed on the monitor.
3. Connect the serial cable from the camera to a serial device such as a keyboard, and confirm that the camera is responding to serial commands. Before using serial communications, it may be necessary to configure the serial device interface to operate with the camera. When the camera is turned on, the video temporarily displays system information including the serial number, IP address, Pelco address, Baud rate, and setting of the serial control DIP switch: SW (software control—the default) or HW (hardware).

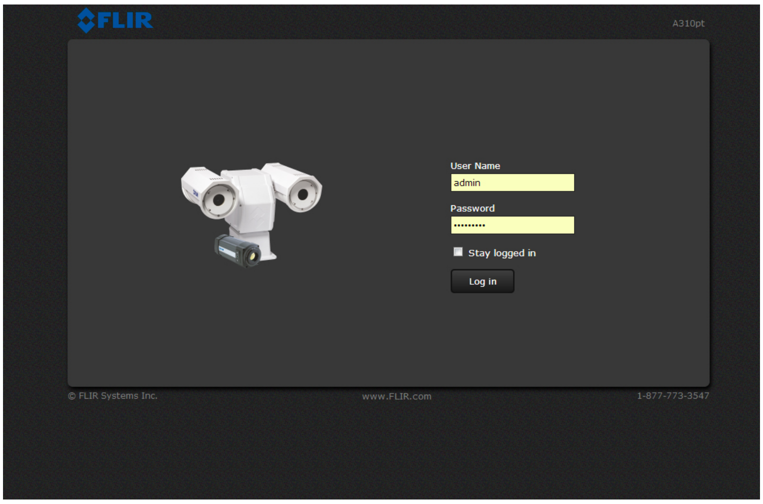
   - S/N: 1234567
   - IP Addr: 192.168.250.116
   - PelcoD (Addr:1): 9600 SW

10.2 IP communications

As shipped from the factory, the FLIR G300 pt series camera has an IP address of 192.168.250.116 with a netmask of 255.255.255.0.

Follow this procedure:

1. Configure a laptop or PC with another IP address from this network (i.e., 192.168.250.xxx).
2. Connect the camera and the laptop to the same Ethernet switch (or back-to-back with an Ethernet crossover cable). In some cases, a straight Ethernet cable can be used because many PCs have auto detect Ethernet interfaces.
3. Open a web browser, enter 192.168.250.116 in the address bar, and press Enter. If the following screen appears, then you have established IP communications with the camera.



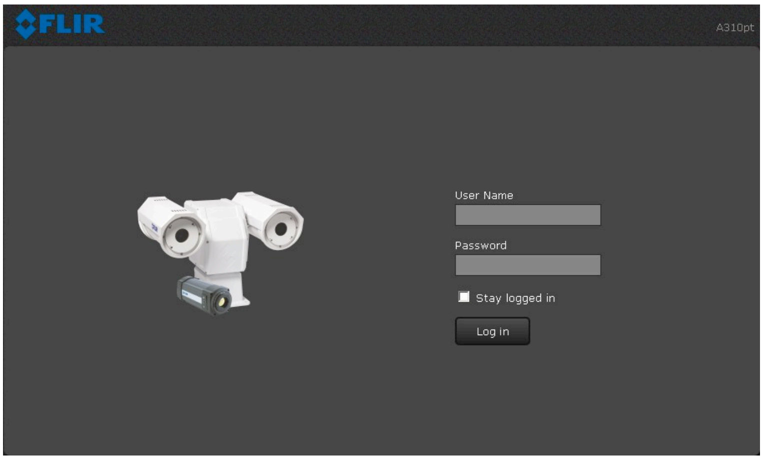
Note The credentials are the following:

- User name: admin
- Password: fliradmin

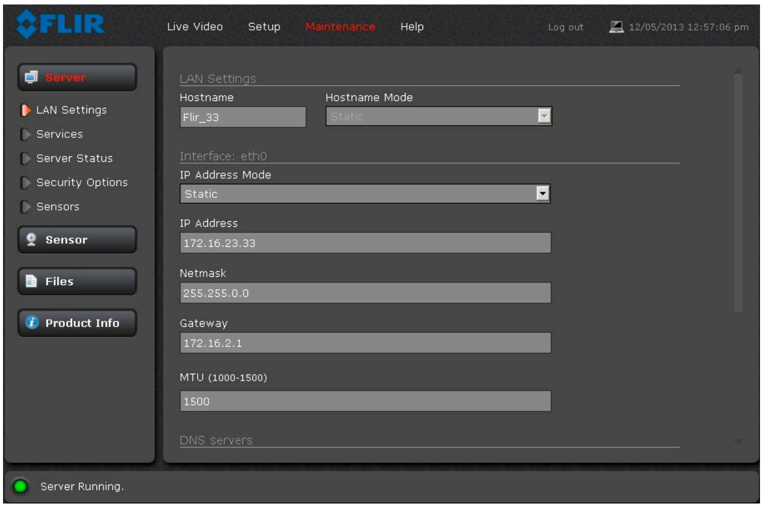
10.3 FLIR G300 pt series camera configuration

Follow this procedure:

1. Open a web browser, enter http://192.168.250.116 in the address bar, and press Enter. This displays the following screen.



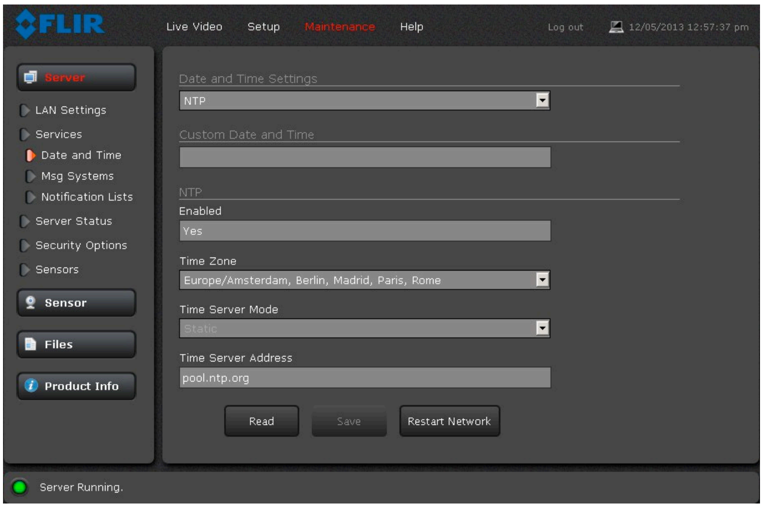
2. Log in using user name: **admin** and password: **fliradmin**.
3. Under *Server*, click *LAN Settings*. This displays the following screen.



4. Under *LAN Settings*, you can change the following parameters:

- *Host name*.
- *Host name mode*.
- *IP Address*.
- *IP Address mode*.
- *Netmask*.
- *Gateway*.
- *MTU*.

5. Under *Services*, click *Date and Time*. This displays the following screen.



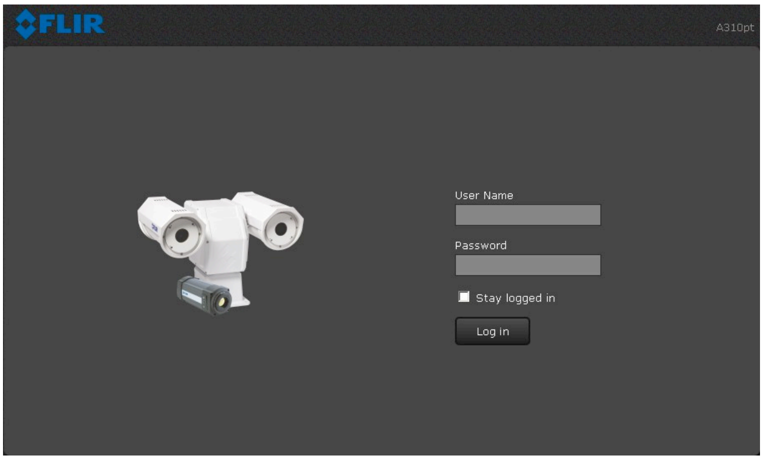
6. Under *Date and Time*, you can change the following parameters:
   - *Date and Time Settings*: *NTP* (to use a time server) or *Custom* (to enter a custom time).

     Note If you select *NTP*, also select *Time Zone* below. You must also set name servers. See section 10.4 *Setting DNS name servers*, page 19 for more information.
   - *Custom Date & Time*.
   - *Time zone*.
   - *Time Server Mode*.
   - *Time Server Address*.

10.4 Setting DNS name servers

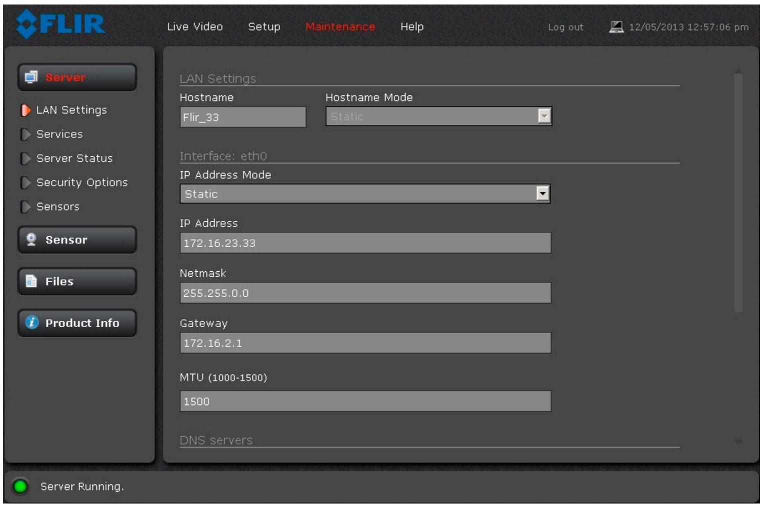
Follow this procedure:

1. Open a web browser, enter http://192.168.250.116 in the address bar, and press Enter. This displays the following screen.

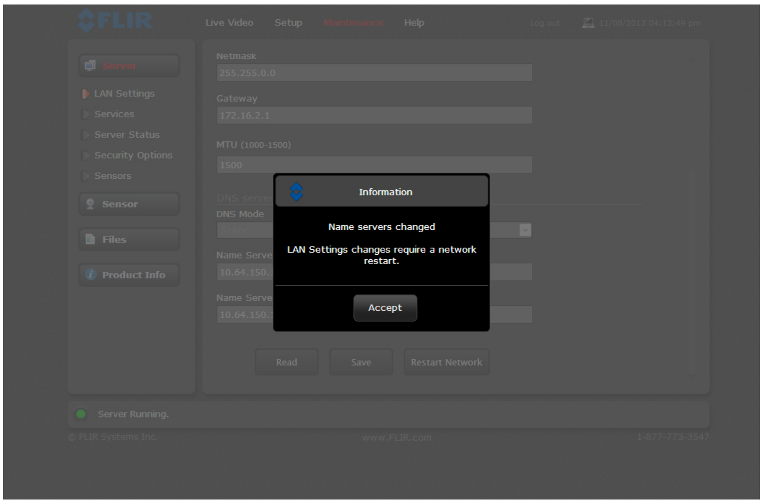


2. Log in using user name: **admin** and password: **fliradmin**.

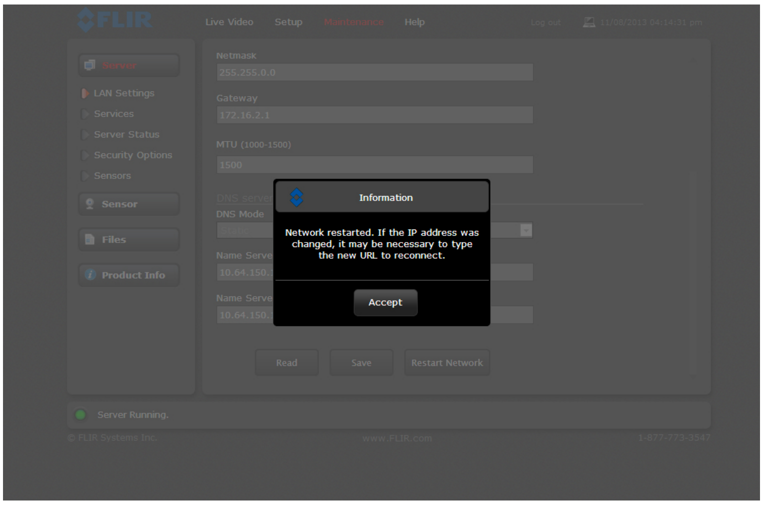
3. On the top menu bar, click *Maintenance*. This displays the following screen.



4. Scroll down to *DNS servers*.
5. Enter at least one name server.
6. Click *Save*. This displays a screen where you need to accept the name server change. Click *Accept*.



7. Click *Restart Network*. This displays a screen where you need to accept typing in the new URL to reconnect. Click *Accept*.



11 Network troubleshooting

Try one of the following if you experience network problems:

- Reset the modem and unplug and replug the Ethernet cable at both ends.
- Reboot the computer with the cables connected.
- Swap your Ethernet cable with another cable that is either brand new or known to be in working condition.
- Connect your Ethernet cable to a different wall socket. If you are still not able to get online, you are probably experiencing a configuration issue.
- Verify your IP address.
- Disable Network Bridging.
- Disable your Wi-Fi connectivity (if you use it) to ensure that the wired Ethernet port is open.
- Renew the DHCP license.
- Make sure that the firewall is turned off when you troubleshoot.
- Make sure that your wireless adapter is switched off. If not, the search for the camera might only look for a wireless connection.
- Normally a modern computer will handle both crossed and uncrossed cable types automatically, but for troubleshooting purposes try both or use a switch.
- Turn off any network adapters that are not connected to the camera.
- For troubleshooting purposes, power both the camera and the computer using a mains adapter. Some laptops turn off the network card to save power when using the battery.

If none of these steps help you, contact your ISP.

12 Technical data

12.1 Online field-of-view calculator

Please visit http://support.flir.com and click the photo of the camera series for field-of-view tables for all lens–camera combinations.

12.2 Note about technical data

FLIR Systems reserves the right to change specifications at any time without prior notice. Please check http://support.flir.com for latest changes.

12.3 Note about authoritative versions

The authoritative version of this publication is English. In the event of divergences due to translation errors, the English text has precedence.

Any late changes are first implemented in English.

12.4 FLIR G300 pt 14.5° NTSC

P/N: 65502-0101
Rev.: 35207

General description
The FLIR G300 pt is a pan/tilt infrared camera for optical gas imaging (OGI) that visualizes and pinpoints leaks of volatile organic compounds (VOCs) without the need to shut down the operation. The FLIR G300 pt is used in industrial settings such as oil refineries, natural gas processing plants, offshore platforms, chemical/petrochemical industries, and biogas and power generation plants. The FLIR G300 pt precision pan/tilt mechanism gives operators accurate directional control while providing fully programmable scan patterns, radar slew-to-cue, and slew-to-alarm functionality.
Key features • H.264, MPEG-4, and MJPEG streaming. • Built-in web server. • 100 Mbps Ethernet (100 m cable, wireless, fiber, etc.). • Composite video output. • Precise pan/tilt mechanism. • Daylight camera. • IP66 encapsulation. • IP control: The FLIR G300 pt can be integrated into any existing TCP/IP network and controlled with a PC. • Serial control interface: Pelco D or Bosch commands can be used over RS-232, RS-422, or RS-485 to remotely control a FLIR G300 pt camera. • Multi-camera software: FLIR Sensors Manager allows users to manage and control a FLIR G300 pt in a TCP/IP network. **Benefits** • Improved efficiency: The FLIR G300 pt reduces revenue loss by pinpointing even small gas leaks quickly and efficiently, and from a distance. It also reduces the inspection time by allowing a broad area to be scanned rapidly and without the need to interrupt the industrial process. • Increased worker safety: OGI allows gas leaks to be detected in a non-contact mode and from a safe distance. This reduces the risk of the user being exposed to invisible and potentially harmful or explosive chemicals. With a G300 pt gas imaging camera unit it is easy to scan areas of interest that are difficult to reach with conventional methods. • Protecting the environment: Several VOCs are dangerous to human health or cause harm to the environment, and are usually governed by regulations. Even small leaks can be detected and documented using the FLIR G300 pt.
Detects the following gases: benzene, ethanol, ethylbenzene, heptane, hexane, isoprene, methanol, methyl ethyl ketone, MIBK, octane, pentane, 1-pentene, toluene, *m*-xylene, ethane, butane, methane, propane, ethylene, propylene.

Imaging and optical data	
IR resolution	320 × 240 pixels
Thermal sensitivity/NETD	<15 mK @ +30°C (+86°F)
Field of view (FOV)	14.5° × 10.8°
Minimum focus distance	0.5 m (1.64 ft.)
Focal length	38 mm (1.49 in.)
F-number	1.5
Focus	Automatic using FLIR SDK, or manual
Zoom	1–8× continuous, digital zoom
Digital image enhancement	Noise reduction filter, high sensitivity mode (HSM)

Detector data	
Detector type	Focal plane array (FPA), cooled InSb
Spectral range	3.2–3.4 µm
Sensor cooling	Stirling Microcooler (FLIR MC-3)

Detector data	
MTBF	2 years or 15,000 hours (whichever is greatest), for a camera running 24/7 @ +20°C (+68°F)
Detects following gases	Benzene, ethanol, ethylbenzene, heptane, hexane, isoprene, methanol, methyl ethyl ketone, MIBK, octane, pentane, 1-pentene, toluene, m-xylene, ethane, butane, methane, propane, ethylene, propylene

Imaging and optical data (visual camera)	
Field of view (FOV)	57.8° (H) to 1.7° (H)
Focal length	3.4 mm (wide) to 122.4 mm (tele)
F-number	1.6 to 4.5
Focus	Automatic or manual (built in motor)
Optical Zoom	36× continuous
Electronic Zoom	12× continuous, digital, interpolating

Detector data (visual camera)	
Focal plane array (FPA)	1/4” Exview HAD CCD
Effective pixels	380.000

Technical specification (pan & tilt)	
Azimuth Range	Az velocity 360° continuous, 0.1 to 60°/sec max
Elevation Range	El velocity ± 45°, 0.1 to 30°/sec. max
Programmable presets	128
Automatic heaters	Clears window from ice. Switched on at +4°C (39° F). Switched off at +15°C (59°F).

Ethernet	
Ethernet	Control, result and image
Ethernet, type	100 Mbps
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	TCP/IP socket-based FLIR proprietary
Ethernet, video streaming	Two independent channels for each camera - MPEG-4, H.264, or M-JPEG
Ethernet, protocols	TCP, UDP, SNTP, RTSP, RTP, HTTP, ICMP, IGMP, ftp, SMTP, SMB (CIFS), DHCP, MDNS (Bonjour), uPnP

Composite video	
Video out	Composite video output, NTSC compatible
Video, standard	CVBS (SMPTE 170M NTSC)

Power system	
Power	24 VAC (21–30 VAC; 24 VAC: 215 VA max. with heater) or 24 VDC (21–30 VDC; 24 VDC: 200 W max. with heater)

Environmental data	
Operating temperature range	–40°C to +50°C (–40°F to +122°F)
Storage temperature range	–40°C to +60°C (–40°F to +140°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
Directives	• Low voltage directive: 2006/95/EC • EMC: 2004/108/EC • RoHS: 2002/95/EC • WEEE: 2002/96/EC
EMC	• EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission) • EN 61 000-4-8, L5
Encapsulation	IP 66 (IEC 60529)
Bump	5 g, 11 ms (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)

Physical data	
Weight	18.7 kg (41.2 lb.)
Size (L × W × H)	460 × 467 × 326 mm (18.1 × 18.4 × 12.8 in.)
Housing material	Aluminum

Shipping information	
Packaging, type	Cardboard box
List of contents	• Infrared camera • Printed documentation • Small parts accessory kit • ThermoVision System Tools & Utilities CD-ROM
Packaging, weight	
Packaging, size	670 × 570 × 490 mm (26.4 × 22.4 × 19.3 in.)
EAN-13	7332558008430
UPC-12	845188008789
Country of origin	Sweden

Supplies & accessories:

- T911288ACC; Pole mount adapter for wall mount kit

12.5 FLIR G300 pt 14.5° PAL

P/N: 65501-0101
Rev.: 35207

General description
The FLIR G300pt is a pan/tilt infrared camera for optical gas imaging (OGI) that visualizes and pinpoints leaks of volatile organic compounds (VOCs) without the need to shut down the operation. The FLIR G300pt is used in industrial settings such as oil refineries, natural gas processing plants, offshore platforms, chemical/petrochemical industries, and biogas and power generation plants. The FLIR G300pt precision pan/tilt mechanism gives operators accurate directional control while providing fully programmable scan patterns, radar slew-to-cue, and slew-to-alarm functionality.
Key features • H.264, MPEG-4, and MJPEG streaming. • Built-in web server. • 100 Mbps Ethernet (100 m cable, wireless, fiber, etc.). • Composite video output. • Precise pan/tilt mechanism. • Daylight camera. • IP66 encapsulation. • IP control: The FLIR G300pt camera can be integrated into any existing TCP/IP network and controlled with a PC. • Serial control interface: Pelco D or Bosch commands can be used over RS-232, RS-422, or RS-485 to remotely control a FLIR G300pt camera. • Multi-camera software: FLIR Sensors Manager allows users to manage and control a FLIR G300pt camera in a TCP/IP network. **Benefits** • Improved efficiency: The FLIR G300pt reduces revenue loss by pinpointing even small gas leaks quickly and efficiently, and from a distance. It also reduces the inspection time by allowing a broad area to be scanned rapidly and without the need to interrupt the industrial process. • Increased worker safety: OGI allows gas leaks to be detected in a non-contact mode and from a safe distance. This reduces the risk of the user being exposed to invisible and potentially harmful or explosive chemicals. With a FLIR G300pt gas imaging camera it is easy to scan areas of interest that are difficult to reach with conventional methods. • Protecting the environment: Several VOCs are dangerous to human health or cause harm to the environment, and are usually governed by regulations. Even small leaks can be detected and documented using the FLIR G300pt.
Detects the following gases: benzene, ethanol, ethylbenzene, heptane, hexane, isoprene, methanol, methyl ethyl ketone, MIBK, octane, pentane, 1-pentene, toluene, *m*-xylene, ethane, butane, methane, propane, ethylene, propylene.

Imaging and optical data	
IR resolution	320 × 240 pixels
Thermal sensitivity/NETD	<15 mK @ +30°C (+86°F)
Field of view (FOV)	14.5° × 10.8°
Minimum focus distance	0.5 m (1.64 ft.)
Focal length	38 mm (1.49 in.)
F-number	1.5
Focus	Automatic using FLIR SDK, or manual
Zoom	1–8× continuous, digital zoom
Digital image enhancement	Noise reduction filter, high sensitivity mode (HSM)

Detector data	
Detector type	Focal plane array (FPA), cooled InSb
Spectral range	3.2–3.4 µm
Sensor cooling	Stirling Microcooler (FLIR MC-3)

Detector data	
MTBF	2 years or 15,000 hours (whichever is greatest), for a camera running 24/7 @ +20°C (+68°F)
Detects following gases	Benzene, ethanol, ethylbenzene, heptane, hexane, isoprene, methanol, methyl ethyl ketone, MIBK, octane, pentane, 1-pentene, toluene, m-xylene, ethane, butane, methane, propane, ethylene, propylene

Imaging and optical data (visual camera)	
Field of view (FOV)	57.8° (H) to 1.7° (H)
Focal length	3.4 mm (wide) to 122.4 mm (tele)
F-number	1.6 to 4.5
Focus	Automatic or manual (built in motor)
Optical Zoom	36× continuous
Electronic Zoom	12× continuous, digital, interpolating

Detector data (visual camera)	
Focal plane array (FPA)	1/4” Exview HAD CCD
Effective pixels	380.000

Technical specification (pan & tilt)	
Azimuth Range	Az velocity 360° continuous, 0.1 to 60°/sec max
Elevation Range	El velocity ± 45°, 0.1 to 30°/sec. max
Programmable presets	128
Automatic heaters	Clears window from ice. Switched on at +4°C (39° F). Switched off at +15°C (59°F).

Ethernet	
Ethernet	Control, result and image
Ethernet, type	100 Mbps
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	TCP/IP socket-based FLIR proprietary
Ethernet, video streaming	Two independent channels for each camera - MPEG-4, H.264, or M-JPEG
Ethernet, protocols	TCP, UDP, SNTP, RTSP, RTP, HTTP, ICMP, IGMP, ftp, SMTP, SMB (CIFS), DHCP, MDNS (Bonjour), uPnP

Composite video	
Video out	Composite video output, PAL compatible
Video, standard	CVBS (ITU-R-BT.470 PAL)

Power system	
Power	24 VAC (21-30 VAC; 24 VAC: 215 VA max. with heater) or 24 VDC (21-30 VDC; 24 VDC: 195 W max. with heater).

Environmental data	
Operating temperature range	–40°C to +50°C (–40°F to +122°F)
Storage temperature range	–40°C to +60°C (–40°F to +140°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
Directives	• Low voltage directive: 2006/95/EC • EMC: 2004/108/EC • RoHS: 2002/95/EC • WEEE: 2002/96/EC
EMC	• EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission) • EN 61 000-4-8, L5
Encapsulation	IP 66 (IEC 60529)
Bump	5 g, 11 ms (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)

Physical data	
Weight	18.7 kg (41.2 lb.)
Size (L × W × H)	460 × 467 × 326 mm (18.1 × 18.4 × 12.8 in.)
Housing material	Aluminum

Shipping information	
List of contents	• Infrared camera • Printed documentation • Small parts accessory kit • ThermoVision System Tools & Utilities CD-ROM
EAN-13	7332558008423
UPC-12	845188008772
Country of origin	Sweden

Supplies & accessories:

- T911288ACC; Pole mount adapter for wall mount kit

12.6 FLIR G300 pt 24° NTSC

P/N: 65502-0102
Rev.: 35207

General description
The FLIR G300 pt is a pan/tilt infrared camera for optical gas imaging (OGI) that visualizes and pinpoints leaks of volatile organic compounds (VOCs) without the need to shut down the operation. The FLIR G300 pt is used in industrial settings such as oil refineries, natural gas processing plants, offshore platforms, chemical/petrochemical industries, and biogas and power generation plants. The FLIR G300 pt precision pan/tilt mechanism gives operators accurate directional control while providing fully programmable scan patterns, radar slew-to-cue, and slew-to-alarm functionality.
Key features • H.264, MPEG-4, and MJPEG streaming. • Built-in web server. • 100 Mbps Ethernet (100 m cable, wireless, fiber, etc.). • Composite video output. • Precise pan/tilt mechanism. • Daylight camera. • IP66 encapsulation. • IP control: The FLIR G300 pt can be integrated into any existing TCP/IP network and controlled with a PC. • Serial control interface: Pelco D or Bosch commands can be used over RS-232, RS-422, or RS-485 to remotely control a FLIR G300 pt camera. • Multi-camera software: FLIR Sensors Manager allows users to manage and control a FLIR G300 pt in a TCP/IP network. **Benefits** • Improved efficiency: The FLIR G300 pt reduces revenue loss by pinpointing even small gas leaks quickly and efficiently, and from a distance. It also reduces the inspection time by allowing a broad area to be scanned rapidly and without the need to interrupt the industrial process. • Increased worker safety: OGI allows gas leaks to be detected in a non-contact mode and from a safe distance. This reduces the risk of the user being exposed to invisible and potentially harmful or explosive chemicals. With a G300 pt gas imaging camera unit it is easy to scan areas of interest that are difficult to reach with conventional methods. • Protecting the environment: Several VOCs are dangerous to human health or cause harm to the environment, and are usually governed by regulations. Even small leaks can be detected and documented using the FLIR G300 pt.
Detects the following gases: benzene, ethanol, ethylbenzene, heptane, hexane, isoprene, methanol, methyl ethyl ketone, MIBK, octane, pentane, 1-pentene, toluene, *m*-xylene, ethane, butane, methane, propane, ethylene, propylene.

Imaging and optical data	
IR resolution	320 × 240 pixels
Thermal sensitivity/NETD	<15 mK @ +30°C (+86°F)
Field of view (FOV)	24° × 18°
Minimum focus distance	0.3 m (1.0 ft.)
Focal length	23 mm (0.89 in.)
F-number	1.5
Focus	Automatic using FLIR SDK, or manual
Zoom	1–8× continuous, digital zoom
Digital image enhancement	Noise reduction filter, high sensitivity mode (HSM)

Detector data	
Detector type	Focal plane array (FPA), cooled InSb
Spectral range	3.2–3.4 µm
Sensor cooling	Stirling Microcooler (FLIR MC-3)

Detector data	
MTBF	2 years or 15,000 hours (whichever is greatest), for a camera running 24/7 @ +20°C (+68°F)
Detects following gases	Benzene, ethanol, ethylbenzene, heptane, hexane, isoprene, methanol, methyl ethyl ketone, MIBK, octane, pentane, 1-pentene, toluene, m-xylene, ethane, butane, methane, propane, ethylene, propylene

Imaging and optical data (visual camera)	
Field of view (FOV)	57.8° (H) to 1.7° (H)
Focal length	3.4 mm (wide) to 122.4 mm (tele)
F-number	1.6 to 4.5
Focus	Automatic or manual (built in motor)
Optical Zoom	36× continuous
Electronic Zoom	12× continuous, digital, interpolating

Detector data (visual camera)	
Focal plane array (FPA)	1/4” Exview HAD CCD
Effective pixels	380.000

Technical specification (pan & tilt)	
Azimuth Range	Az velocity 360° continuous, 0.1 to 60°/sec max
Elevation Range	El velocity +/- 45°, 0.1 to 30°/sec. max
Programmable presets	128
Automatic heaters	Clears window from ice. Switched on at +4°C (39° F). Switched off at +15°C (59°F).

Ethernet	
Ethernet	Control, result and image
Ethernet, type	100 Mbps
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	TCP/IP socket-based FLIR proprietary
Ethernet, video streaming	Two independent channels for each camera - MPEG-4, H.264, or M-JPEG
Ethernet, protocols	TCP, UDP, SNTP, RTSP, RTP, HTTP, ICMP, IGMP, ftp, SMTP, SMB (CIFS), DHCP, MDNS (Bonjour), uPnP

Composite video	
Video out	Composite video output, NTSC compatible
Video, standard	CVBS (SMPTE 170M NTSC)

Power system	
Power	24 VAC (21–30 VAC; 24 VAC: 215 VA max. with heater) or 24 VDC (21–30 VDC; 24 VDC: 200 W max. with heater)

Environmental data	
Operating temperature range	–40°C to +50°C (–40°F to +122°F)
Storage temperature range	–40°C to +60°C (–40°F to +140°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
Directives	• Low voltage directive: 2006/95/EC • EMC: 2004/108/EC • RoHS: 2002/95/EC • WEEE: 2002/96/EC
EMC	• EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission) • EN 61 000-4-8, L5
Encapsulation	IP 66 (IEC 60529)
Bump	5 g, 11 ms (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)

Physical data	
Weight	18.7 kg (41.2 lb.)
Size (L × W × H)	460 × 467 × 326 mm (18.1 × 18.4 × 12.8 in.)
Housing material	Aluminum

Shipping information	
Packaging, type	Cardboard box
List of contents	• Infrared camera • Printed documentation • Small parts accessory kit • ThermoVision System Tools & Utilities CD-ROM
Packaging, weight	23.4 kg (51.6 lb.)
Packaging, size	670 × 570 × 490 mm (26.4 × 22.4 × 19.3 in.)
EAN-13	7332558008454
UPC-12	845188008802
Country of origin	Sweden

Supplies & accessories:

- T911288ACC; Pole mount adapter for wall mount kit

12.7 FLIR G300 pt 24° PAL

P/N: 65501-0102
Rev.: 35207

General description
The FLIR G300pt is a pan/tilt infrared camera for optical gas imaging (OGI) that visualizes and pinpoints leaks of volatile organic compounds (VOCs) without the need to shut down the operation. The FLIR G300pt is used in industrial settings such as oil refineries, natural gas processing plants, offshore platforms, chemical/petrochemical industries, and biogas and power generation plants. The FLIR G300pt precision pan/tilt mechanism gives operators accurate directional control while providing fully programmable scan patterns, radar slew-to-cue, and slew-to-alarm functionality.
Key features • H.264, MPEG-4, and MJPEG streaming. • Built-in web server. • 100 Mbps Ethernet (100 m cable, wireless, fiber, etc.). • Composite video output. • Precise pan/tilt mechanism. • Daylight camera. • IP66 encapsulation. • IP control: The FLIR G300pt camera can be integrated into any existing TCP/IP network and controlled with a PC. • Serial control interface: Pelco D or Bosch commands can be used over RS-232, RS-422, or RS-485 to remotely control a FLIR G300pt camera. • Multi-camera software: FLIR Sensors Manager allows users to manage and control a FLIR G300pt camera in a TCP/IP network. **Benefits** • Improved efficiency: The FLIR G300pt reduces revenue loss by pinpointing even small gas leaks quickly and efficiently, and from a distance. It also reduces the inspection time by allowing a broad area to be scanned rapidly and without the need to interrupt the industrial process. • Increased worker safety: OGI allows gas leaks to be detected in a non-contact mode and from a safe distance. This reduces the risk of the user being exposed to invisible and potentially harmful or explosive chemicals. With a FLIR G300pt gas imaging camera it is easy to scan areas of interest that are difficult to reach with conventional methods. • Protecting the environment: Several VOCs are dangerous to human health or cause harm to the environment, and are usually governed by regulations. Even small leaks can be detected and documented using the FLIR G300pt.
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Ethernet, protocols	TCP, UDP, SNTP, RTSP, RTP, HTTP, ICMP, IGMP, ftp, SMTP, SMB (CIFS), DHCP, MDNS (Bonjour), uPnP

Composite video	
Video out	Composite video output, PAL compatible
Video, standard	CVBS (ITU-R-BT.470 PAL)

Power system	
Power	24 VAC (21-30 VAC; 24 VAC: 215 VA max. with heater) or 24 VDC (21-30 VDC; 24 VDC: 195 W max. with heater).

Environmental data	
Operating temperature range	–40°C to +50°C (—40°F to +122°F)
Storage temperature range	–40°C to +60°C (–40°F to +140°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
Directives	• Low voltage directive: 2006/95/EC • EMC: 2004/108/EC • RoHS: 2002/95/EC • WEEE: 2002/96/EC
EMC	• EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission) • EN 61 000-4-8, L5
Encapsulation	IP 66 (IEC 60529)
Bump	5 g, 11 ms (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)

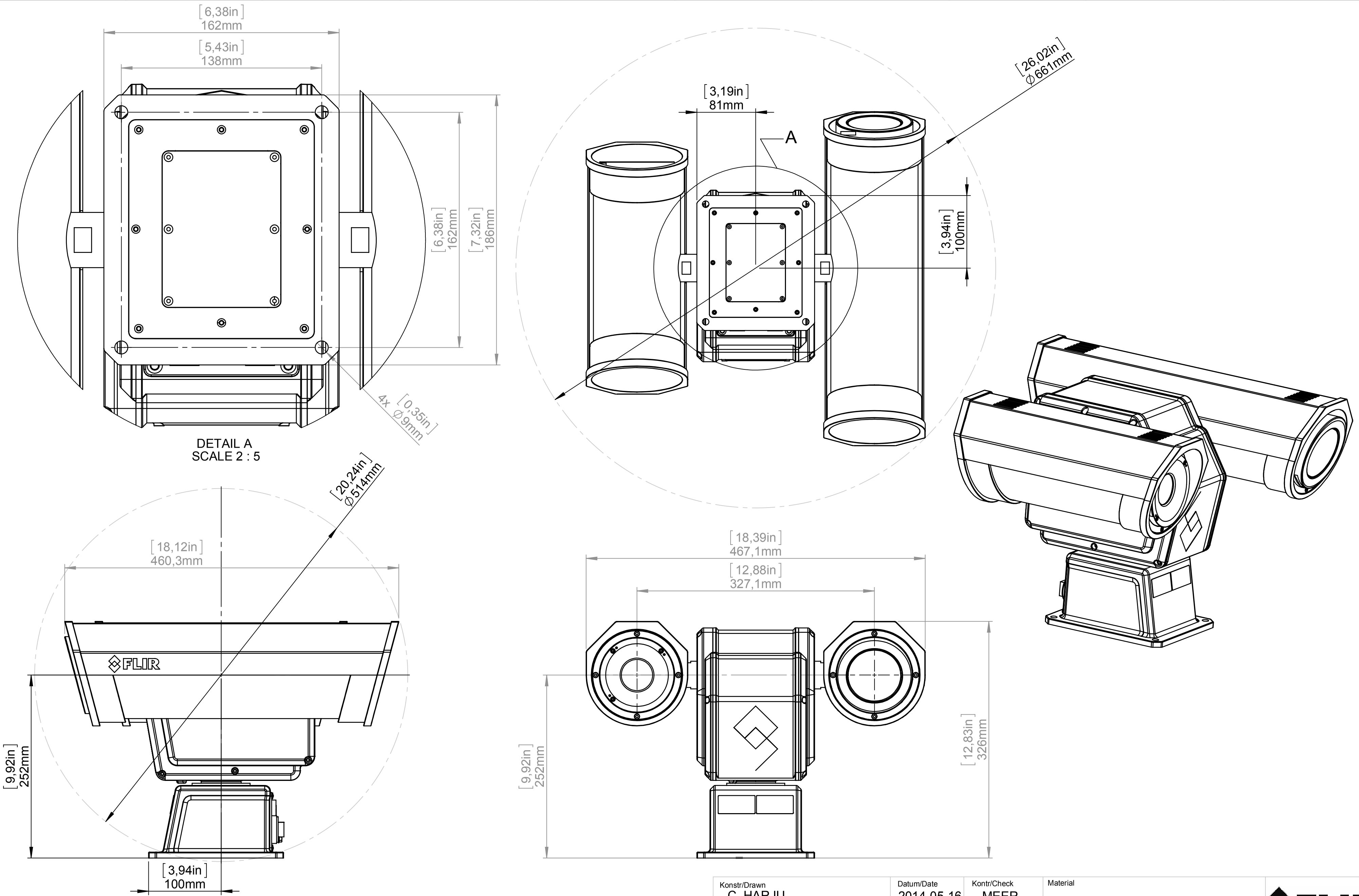
Physical data	
Weight	18.7 kg (41.2 lb.)
Size (L × W × H)	460 × 467 × 326 mm (18.1 × 18.4 × 12.8 in.)
Housing material	Aluminum

Shipping information	
List of contents	• Infrared camera • Printed documentation • Small parts accessory kit • ThermoVision System Tools & Utilities CD-ROM
EAN-13	7332558008447
UPC-12	845188008796
Country of origin	Sweden

Supplies & accessories:

- T911288ACC; Pole mount adapter for wall mount kit

13 Mechanical drawings



All dimensions are valid for FOV 14,5° and 24°

Konstr/Drawn: C. HARJU	Datum/Date: 2014-05-16	Kontr/Check: MEER	Material: -	FLIR
Ändrad av/Modified by: M. MOOIJ	Ändrad/Modified: 2014-06-27	Ytjämnhet/Roughness: Ra µm	Ytbehandling/Surface treatment	
Där ej annat anges/Unless otherwise stated Gen tol ISO 2768-mK Utdrag ur/Excerpt from ISO 2768-m	Benämning/Denomination: G300pt basic dimensions		Skala/Scale: 1:5	Blad/Sheet: 1(1)
			ArtNo.	Size: A3
			Ritn nr/Drawing No: T128314	Rev: A

0,5-6	±0,1	Hålkälsradier Fillet radii
(6)-30	±0,2	
(30)-120	±0,3	
(120)-400	±0,5	Kanter brutna Edges broken
(400)-1000	±0,8	

14 CE Declaration of conformity

October 29, 2014 AQ320094

CE Declaration of Conformity

This is to certify that the System listed below have been designed and manufactured to meet the requirements, as applicable, of the following EU-Directives and corresponding harmonising standards. The systems consequently meet the requirements for the CE-mark.

Directives:

Directive 2004/108/EC; Electromagnetic Compatibility

Standards:

Emission:	**EN 61000-6-4;**	**Electro magnetic Compatibility Generic standards - Emission**
Immunity:	**EN 61000-6-2;**	**Electro magnetic Compatibility; Generic standards - Immunity**

System: **FLIR G300pt series**

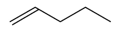
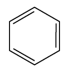
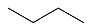
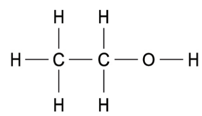
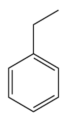
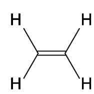
FLIR Systems AB
Quality Assurance

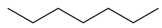
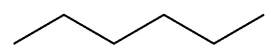
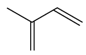
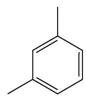
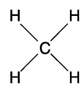
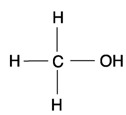
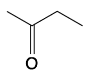
Björn Svensson
Director

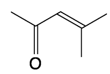
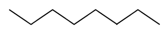
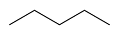
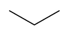
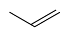
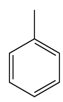
FLIR Systems AB • Antennvägen 6 • P.O. Box 7376 • SE-187 15 Täby • Sweden
Telephone: +46 8 753 25 00 • Telefax: +46 8 753 23 64
Registered No: 556256-6579
www.flir.se

15 Detectable gases

The FLIR G300 pt camera has been engineered and designed to detect various gases. This table lists the gases that FLIR Systems has tested at various concentrations within the laboratory.

Common name	Molecular formula	Structural formula
1-Pentene	C_5H_{10}	
Benzene	C_6H_6	
Butane	C_4H_{10}	
Ethane	C_2H_6	
Ethanol	C_2H_6O	
Ethylbenzene	C_8H_{10}	
Ethylene	C_2H_4	

Common name	Molecular formula	Structural formula
Heptane	C_7H_{16}	
Hexane	C_6H_{14}	
Isoprene	C_5H_8	
m-Xylene	C_8H_{10}	
Methane	CH_4	
Methanol	CH_4O	
Methyl ethyl ketone	C_4H_8O	

Common name	Molecular formula	Structural formula
MIBK	$C_6H_{10}O$	
Octane	C_8H_{18}	
Pentane	C_5H_{12}	
Propane	C_3H_8	
Propylene	C_3H_6	
Toluene	C_7H_8	

16 Why do some gases absorb infrared energy?

From a mechanical point of view, molecules in a gas could be compared to weights (the balls in the figures below), connected together via springs. Depending on the number of atoms, their respective size and mass, the elastic constant of the springs, molecules may move in given directions, vibrate along an axis, rotate, twist, stretch, rock, wag, etc.

The simplest gas molecules are single atoms, like helium, neon or krypton. They have no way to vibrate or rotate, so they can only move by translation in one direction at a time.

Figure 16.1 Single atom

The next most complex category of molecules is homonuclear, made of two atoms such as hydrogen (H_2), nitrogen (N_2) and oxygen (O_2). They have the ability to tumble around their axes in addition to translational motion.

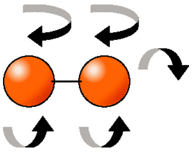


Figure 16.2 Two atoms

Then there are complex diatomic molecules, such as carbon dioxide (CO_2), methane (CH_4), sulfur hexafluoride (SF_6), and styrene ($C_6H_5CH=CH_2$) (these are just a few examples).

Figure 16.3 Carbon dioxide (CO_2), 3 atoms per molecule

This assumption is valid for multi-atomic molecules.

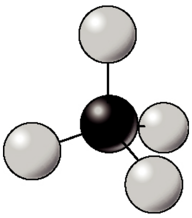


Figure 16.4 Methane (CH_4), 5 atoms per molecule

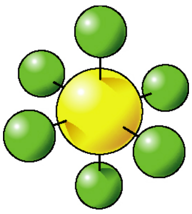


Figure 16.5 Sulfur hexafluoride (SF_6), 7 atoms per molecule

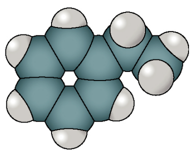


Figure 16.6 Styrene ($C_6H_5CH=CH_2$), 16 atoms per molecule

Their increased degrees of mechanical freedom allow multiple rotational and vibrational transitions. Because they are built from multiple atoms, they can absorb and emit heat more effectively than simple molecules. Depending on the frequency of the transitions, some of them fall into energy ranges that are located in the infrared region where the infrared camera is sensitive.

Transition type	Frequency	Spectral range
Rotation of heavy molecules	10^9–10^{11} Hz	Microwaves, above 3 mm/0.118 in.
Rotation of light molecules and vibration of heavy molecules	10^{11}–10^{13} Hz	Far infrared, between 30 µm and 3 mm/0.118 in.
Vibration of light molecules. Rotation and vibration of the structure	10^{13}–10^{14} Hz	Infrared, between 3 µm and 30 µm
Electronic transitions	10^{14}–10^{16} Hz	UV–visible

In order for a molecule to absorb a photon via a transition from one state to another, the molecule must have a dipole moment capable of briefly oscillating at the same frequency as the incident photon. This quantum mechanical interaction allows the electromagnetic field energy of the photon to be “transferred” or absorbed by the molecule.

FLIR GF3xx series cameras take advantage of the absorbing nature of certain molecules, to visualize them in their native environments.

FLIR GF3xx series focal plane arrays and optical systems are specifically tuned to very narrow spectral ranges, in the order of hundreds of nanometers, and are therefore ultra selective. Only gases absorbent in the infrared region that is delimited by a narrow band pass filter can be detected.

Since the energy from the gases is very weak, all camera components are optimized to emit as little energy as possible. This is the only solution to provide a sufficient signal-to-noise ratio. Hence, the filter itself is maintained at a cryogenic temperature: down to 60 K in the case of the FLIR GF3xx series LW camera that was released in the beginning of 2008.

Below, are the transmittance spectra of two gases:

- Benzene (C_6H_6)—absorbent in the MW region
- Sulfur hexafluoride (SF_6)—absorbent in the LW region.

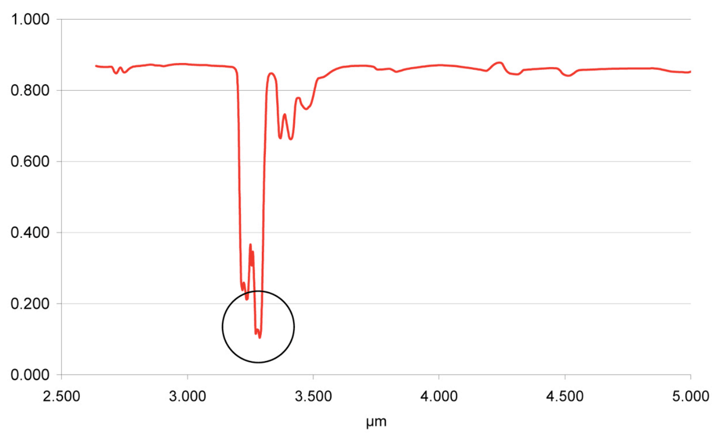


Figure 16.7 Benzene (C_6H_6). Strong absorption around 3.2/3.3 µm

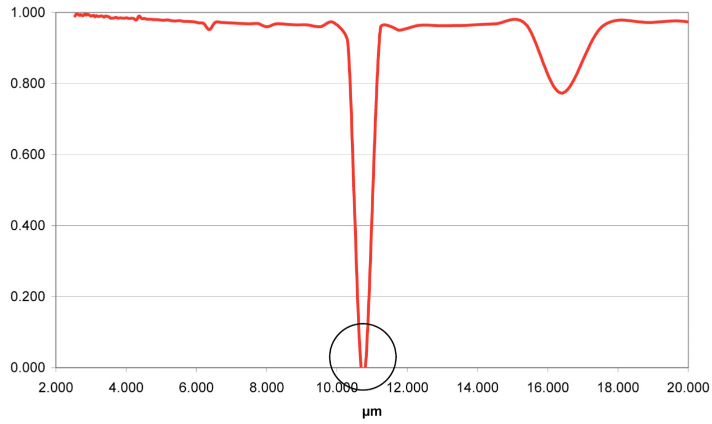


Figure 16.8 Sulfur hexafluoride (SF_6). Strong absorption around 10.6 µm

17 Cleaning the camera

17.1 Camera housing, cables, and other items

17.1.1 Liquids

Use one of these liquids:

- Warm water
- A weak detergent solution

17.1.2 Equipment

A soft cloth

17.1.3 Procedure

Follow this procedure:

1. Soak the cloth in the liquid.
2. Twist the cloth to remove excess liquid.
3. Clean the part with the cloth.

> ⚠ **CAUTION**
>
> Do not apply solvents or similar liquids to the camera, the cables, or other items. This can cause damage.

17.2 Infrared lens

17.2.1 Liquids

Use one of these liquids:

- A commercial lens cleaning liquid with more than 30% isopropyl alcohol.
- 96% ethyl alcohol (C_2H_5OH).

17.2.2 Equipment

Cotton wool

17.2.3 Procedure

Follow this procedure:

1. Soak the cotton wool in the liquid.
2. Twist the cotton wool to remove excess liquid.
3. Clean the lens one time only and discard the cotton wool.

> ⚠ **WARNING**
>
> Make sure that you read all applicable MSDS (Material Safety Data Sheets) and warning labels on containers before you use a liquid: the liquids can be dangerous.

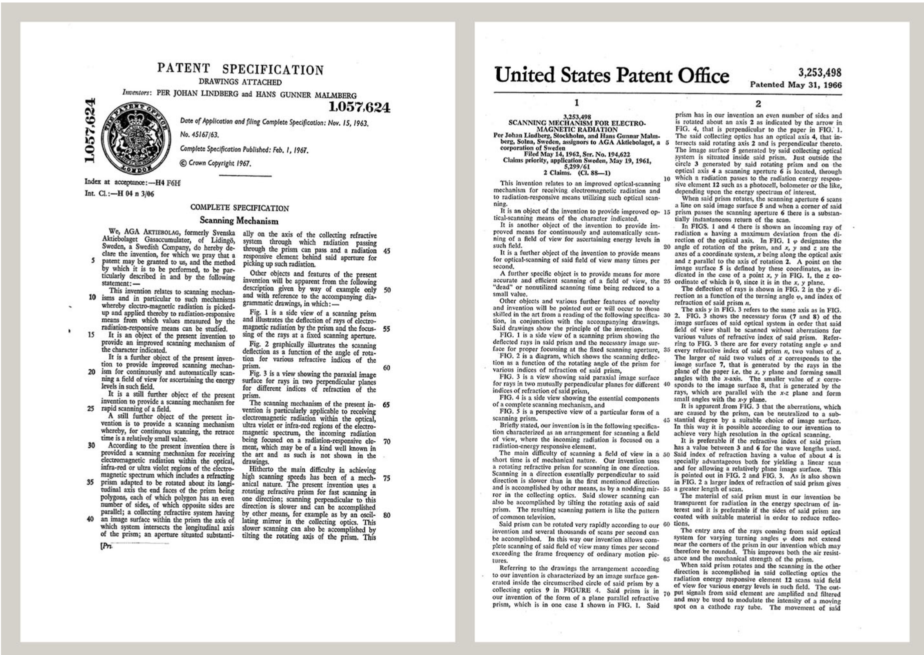
> ⚠ **CAUTION**
>
> - Be careful when you clean the infrared lens. The lens has a delicate anti-reflective coating.
> - Do not clean the infrared lens too vigorously. This can damage the anti-reflective coating.

18 About FLIR Systems

FLIR Systems was established in 1978 to pioneer the development of high-performance infrared imaging systems, and is the world leader in the design, manufacture, and marketing of thermal imaging systems for a wide variety of commercial, industrial, and government applications. Today, FLIR Systems embraces five major companies with outstanding achievements in infrared technology since 1958—the Swedish AGEMA Infrared Systems (formerly AGA Infrared Systems), the three United States companies Indigo Systems, FSI, and Inframetrics, and the French company Cedip.

Since 2007, FLIR Systems has acquired several companies with world-leading expertise in sensor technologies:

- Extech Instruments (2007)
- Ifara Tecnologías (2008)
- Salvador Imaging (2009)
- OmniTech Partners (2009)
- Directed Perception (2009)
- Raymarine (2010)
- ICx Technologies (2010)
- TackTick Marine Digital Instruments (2011)
- Aerius Photonics (2011)
- Lorex Technology (2012)
- Traficon (2012)
- MARSS (2013)
- DigitalOptics micro-optics business (2013)
- DVTEL (2015)


PATENT SPECIFICATION

DRAWINGS ATTACHED

1.057.624

COMPLETE SPECIFICATION

Scanning Mechanism

United States Patent Office

3,253,498

Patented May 31, 1966

SCANNING MECHANISM FOR ELECTRO-MAGNETIC RADIATION

Figure 18.1 Patent documents from the early 1960s

FLIR Systems has three manufacturing plants in the United States (Portland, OR, Boston, MA, Santa Barbara, CA) and one in Sweden (Stockholm). Since 2007 there is also a manufacturing plant in Tallinn, Estonia. Direct sales offices in Belgium, Brazil, China, France, Germany, Great Britain, Hong Kong, Italy, Japan, Korea, Sweden, and the USA —together with a worldwide network of agents and distributors—support our international customer base.

FLIR Systems is at the forefront of innovation in the infrared camera industry. We anticipate market demand by constantly improving our existing cameras and developing new ones. The company has set milestones in product design and development such as the introduction of the first battery-operated portable camera for industrial inspections, and the first uncooled infrared camera, to mention just two innovations.

Figure 18.2 1969: Thermovision Model 661. The camera weighed approximately 25 kg (55 lb.), the oscilloscope 20 kg (44 lb.), and the tripod 15 kg (33 lb.). The operator also needed a 220 VAC generator set, and a 10 L (2.6 US gallon) jar with liquid nitrogen. To the left of the oscilloscope the Polaroid attachment (6 kg/13 lb.) can be seen.

Figure 18.3 2015: FLIR One, an accessory to iPhone and Android mobile phones. Weight: 90 g (3.2 oz.).

FLIR Systems manufactures all vital mechanical and electronic components of the camera systems itself. From detector design and manufacturing, to lenses and system electronics, to final testing and calibration, all production steps are carried out and supervised by our own engineers. The in-depth expertise of these infrared specialists ensures the accuracy and reliability of all vital components that are assembled into your infrared camera.

18.1 More than just an infrared camera

At FLIR Systems we recognize that our job is to go beyond just producing the best infrared camera systems. We are committed to enabling all users of our infrared camera systems to work more productively by providing them with the most powerful camera–software combination. Especially tailored software for predictive maintenance, R & D, and process monitoring is developed in-house. Most software is available in a wide variety of languages.

We support all our infrared cameras with a wide variety of accessories to adapt your equipment to the most demanding infrared applications.

18.2 Sharing our knowledge

Although our cameras are designed to be very user-friendly, there is a lot more to thermography than just knowing how to handle a camera. Therefore, FLIR Systems has founded the Infrared Training Center (ITC), a separate business unit, that provides certified training courses. Attending one of the ITC courses will give you a truly hands-on learning experience.

The staff of the ITC are also there to provide you with any application support you may need in putting infrared theory into practice.

18.3 Supporting our customers

FLIR Systems operates a worldwide service network to keep your camera running at all times. If you discover a problem with your camera, local service centers have all the equipment and expertise to solve it within the shortest possible time. Therefore, there is no need to send your camera to the other side of the world or to talk to someone who does not speak your language.

19 Glossary

absorption (absorption factor)	The amount of radiation absorbed by an object relative to the received radiation. A number between 0 and 1.
atmosphere	The gases between the object being measured and the camera, normally air.
autoadjust	A function making a camera perform an internal image correction.
autopalette	The IR image is shown with an uneven spread of colors, displaying cold objects as well as hot ones at the same time.
blackbody	Totally non-reflective object. All its radiation is due to its own temperature.
blackbody radiator	An IR radiating equipment with blackbody properties used to calibrate IR cameras.
calculated atmospheric transmission	A transmission value computed from the temperature, the relative humidity of air and the distance to the object.
cavity radiator	A bottle shaped radiator with an absorbing inside, viewed through the bottleneck.
color temperature	The temperature for which the color of a blackbody matches a specific color.
conduction	The process that makes heat diffuse into a material.
continuous adjust	A function that adjusts the image. The function works all the time, continuously adjusting brightness and contrast according to the image content.
convection	Convection is a heat transfer mode where a fluid is brought into motion, either by gravity or another force, thereby transferring heat from one place to another.
dual isotherm	An isotherm with two color bands, instead of one.
emissivity (emissivity factor)	The amount of radiation coming from an object, compared to that of a blackbody. A number between 0 and 1.
emittance	Amount of energy emitted from an object per unit of time and area (W/m^2)
environment	Objects and gases that emit radiation towards the object being measured.
estimated atmospheric transmission	A transmission value, supplied by a user, replacing a calculated one
external optics	Extra lenses, filters, heat shields etc. that can be put between the camera and the object being measured.
filter	A material transparent only to some of the infrared wavelengths.
FOV	Field of view: The horizontal angle that can be viewed through an IR lens.
FPA	Focal plane array: A type of IR detector.
graybody	An object that emits a fixed fraction of the amount of energy of a blackbody for each wavelength.
IFOV	Instantaneous field of view: A measure of the geometrical resolution of an IR camera.

image correction (internal or external)	A way of compensating for sensitivity differences in various parts of live images and also of stabilizing the camera.
infrared	Non-visible radiation, having a wavelength from about 2–13 μm.
IR	infrared
isotherm	A function highlighting those parts of an image that fall above, below or between one or more temperature intervals.
isothermal cavity	A bottle-shaped radiator with a uniform temperature viewed through the bottleneck.
Laser LocatIR	An electrically powered light source on the camera that emits laser radiation in a thin, concentrated beam to point at certain parts of the object in front of the camera.
laser pointer	An electrically powered light source on the camera that emits laser radiation in a thin, concentrated beam to point at certain parts of the object in front of the camera.
level	The center value of the temperature scale, usually expressed as a signal value.
manual adjust	A way to adjust the image by manually changing certain parameters.
NETD	Noise equivalent temperature difference. A measure of the image noise level of an IR camera.
noise	Undesired small disturbance in the infrared image
object parameters	A set of values describing the circumstances under which the measurement of an object was made, and the object itself (such as emissivity, reflected apparent temperature, distance etc.)
object signal	A non-calibrated value related to the amount of radiation received by the camera from the object.
palette	The set of colors used to display an IR image.
pixel	Stands for *picture element*. One single spot in an image.
radiance	Amount of energy emitted from an object per unit of time, area and angle ($W/m^2/sr$)
radiant power	Amount of energy emitted from an object per unit of time (W)
radiation	The process by which electromagnetic energy, is emitted by an object or a gas.
radiator	A piece of IR radiating equipment.
range	The current overall temperature measurement limitation of an IR camera. Cameras can have several ranges. Expressed as two blackbody temperatures that limit the current calibration.
reference temperature	A temperature which the ordinary measured values can be compared with.
reflection	The amount of radiation reflected by an object relative to the received radiation. A number between 0 and 1.
relative humidity	Relative humidity represents the ratio between the current water vapour mass in the air and the maximum it may contain in saturation conditions.
saturation color	The areas that contain temperatures outside the present level/span settings are colored with the saturation colors. The saturation colors contain an 'overflow' color and an 'underflow' color. There is also a third red saturation color that marks everything saturated by the detector indicating that the range should probably be changed.

span	The interval of the temperature scale, usually expressed as a signal value.
spectral (radiant) emittance	Amount of energy emitted from an object per unit of time, area and wavelength ($W/m^2/\mu m$)
temperature difference, or difference of temperature.	A value which is the result of a subtraction between two temperature values.
temperature range	The current overall temperature measurement limitation of an IR camera. Cameras can have several ranges. Expressed as two blackbody temperatures that limit the current calibration.
temperature scale	The way in which an IR image currently is displayed. Expressed as two temperature values limiting the colors.
thermogram	infrared image
transmission (or transmittance) factor	Gases and materials can be more or less transparent. Transmission is the amount of IR radiation passing through them. A number between 0 and 1.
transparent isotherm	An isotherm showing a linear spread of colors, instead of covering the highlighted parts of the image.
visual	Refers to the video mode of a IR camera, as opposed to the normal, thermographic mode. When a camera is in video mode it captures ordinary video images, while thermographic images are captured when the camera is in IR mode.

20 Thermographic measurement techniques

20.1 Introduction

An infrared camera measures and images the emitted infrared radiation from an object. The fact that radiation is a function of object surface temperature makes it possible for the camera to calculate and display this temperature.

However, the radiation measured by the camera does not only depend on the temperature of the object but is also a function of the emissivity. Radiation also originates from the surroundings and is reflected in the object. The radiation from the object and the reflected radiation will also be influenced by the absorption of the atmosphere.

To measure temperature accurately, it is therefore necessary to compensate for the effects of a number of different radiation sources. This is done on-line automatically by the camera. The following object parameters must, however, be supplied for the camera:

- The emissivity of the object
- The reflected apparent temperature
- The distance between the object and the camera
- The relative humidity
- Temperature of the atmosphere

20.2 Emissivity

The most important object parameter to set correctly is the emissivity which, in short, is a measure of how much radiation is emitted from the object, compared to that from a perfect blackbody of the same temperature.

Normally, object materials and surface treatments exhibit emissivity ranging from approximately 0.1 to 0.95. A highly polished (mirror) surface falls below 0.1, while an oxidized or painted surface has a higher emissivity. Oil-based paint, regardless of color in the visible spectrum, has an emissivity over 0.9 in the infrared. Human skin exhibits an emissivity 0.97 to 0.98.

Non-oxidized metals represent an extreme case of perfect opacity and high reflexivity, which does not vary greatly with wavelength. Consequently, the emissivity of metals is low – only increasing with temperature. For non-metals, emissivity tends to be high, and decreases with temperature.

20.2.1 Finding the emissivity of a sample

20.2.1.1 Step 1: Determining reflected apparent temperature

Use one of the following two methods to determine reflected apparent temperature:

20.2.1.1.1 Method 1: Direct method

Follow this procedure:

1. Look for possible reflection sources, considering that the incident angle = reflection angle (a = b).

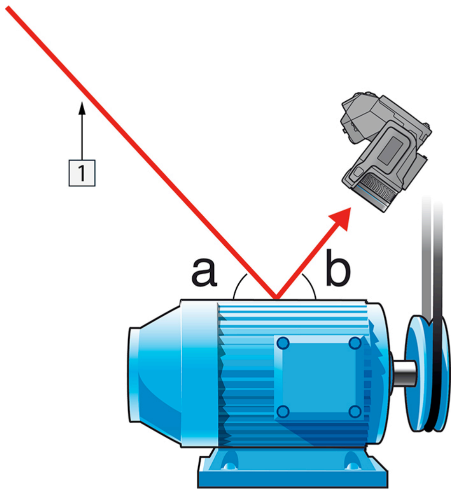


Figure 20.1 1 = Reflection source

2. If the reflection source is a spot source, modify the source by obstructing it using a piece if cardboard.

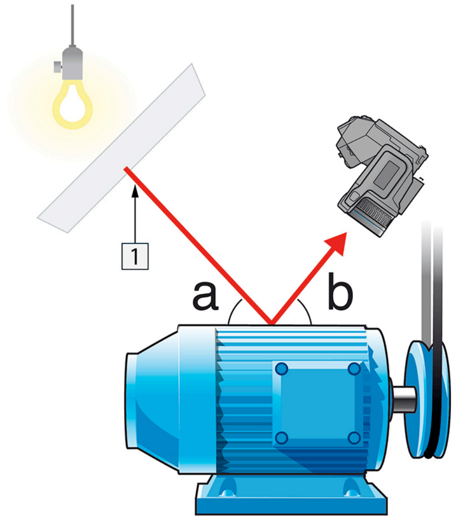


Figure 20.2 1 = Reflection source

3. Measure the radiation intensity (= apparent temperature) from the reflecting source using the following settings:

   - Emissivity: 1.0
   - D_{obj}: 0

   You can measure the radiation intensity using one of the following two methods:

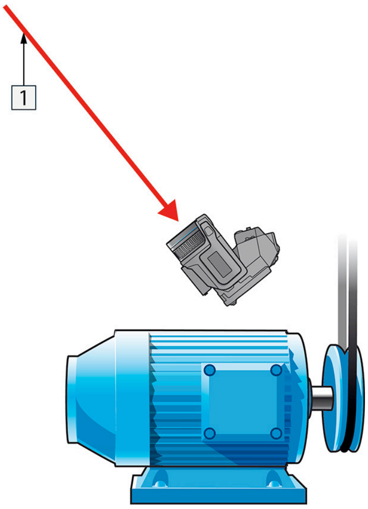


Figure 20.3 1 = Reflection source

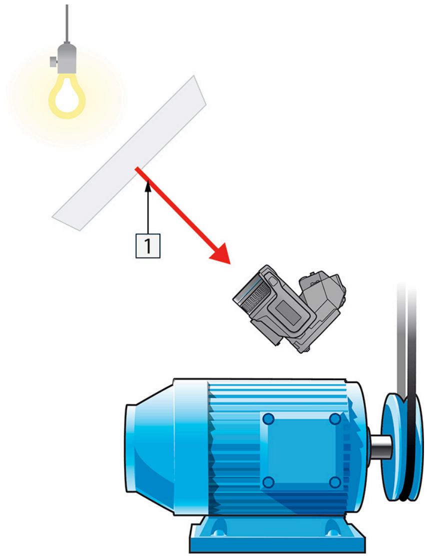


Figure 20.4 1 = Reflection source

Using a thermocouple to measure reflected apparent temperature is not recommended for two important reasons:

- A thermocouple does not measure radiation intensity
- A thermocouple requires a very good thermal contact to the surface, usually by gluing and covering the sensor by a thermal isolator.

20.2.1.1.2 Method 2: Reflector method

Follow this procedure:

1. Crumble up a large piece of aluminum foil.
2. Uncrumble the aluminum foil and attach it to a piece of cardboard of the same size.
3. Put the piece of cardboard in front of the object you want to measure. Make sure that the side with aluminum foil points to the camera.
4. Set the emissivity to 1.0.

5. Measure the apparent temperature of the aluminum foil and write it down.

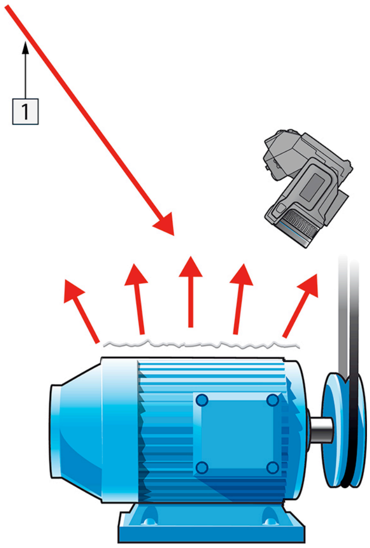


Figure 20.5 Measuring the apparent temperature of the aluminum foil.

20.2.1.2 Step 2: Determining the emissivity

Follow this procedure:

1. Select a place to put the sample.
2. Determine and set reflected apparent temperature according to the previous procedure.
3. Put a piece of electrical tape with known high emissivity on the sample.
4. Heat the sample at least 20 K above room temperature. Heating must be reasonably even.
5. Focus and auto-adjust the camera, and freeze the image.
6. Adjust *Level* and *Span* for best image brightness and contrast.
7. Set emissivity to that of the tape (usually 0.97).
8. Measure the temperature of the tape using one of the following measurement functions:
   - *Isotherm* (helps you to determine both the temperature and how evenly you have heated the sample)
   - *Spot* (simpler)
   - *Box Avg* (good for surfaces with varying emissivity).
9. Write down the temperature.
10. Move your measurement function to the sample surface.
11. Change the emissivity setting until you read the same temperature as your previous measurement.
12. Write down the emissivity.

Note

- Avoid forced convection
- Look for a thermally stable surrounding that will not generate spot reflections
- Use high quality tape that you know is not transparent, and has a high emissivity you are certain of
- This method assumes that the temperature of your tape and the sample surface are the same. If they are not, your emissivity measurement will be wrong.

20.3 Reflected apparent temperature

This parameter is used to compensate for the radiation reflected in the object. If the emissivity is low and the object temperature relatively far from that of the reflected it will be important to set and compensate for the reflected apparent temperature correctly.

20.4 Distance

The distance is the distance between the object and the front lens of the camera. This parameter is used to compensate for the following two facts:

- That radiation from the target is absorbed by the atmosphere between the object and the camera.
- That radiation from the atmosphere itself is detected by the camera.

20.5 Relative humidity

The camera can also compensate for the fact that the transmittance is also dependent on the relative humidity of the atmosphere. To do this set the relative humidity to the correct value. For short distances and normal humidity the relative humidity can normally be left at a default value of 50%.

20.6 Other parameters

In addition, some cameras and analysis programs from FLIR Systems allow you to compensate for the following parameters:

- Atmospheric temperature – *i.e.* the temperature of the atmosphere between the camera and the target
- External optics temperature – *i.e.* the temperature of any external lenses or windows used in front of the camera
- External optics transmittance – *i.e.* the transmission of any external lenses or windows used in front of the camera

21 History of infrared technology

Before the year 1800, the existence of the infrared portion of the electromagnetic spectrum wasn't even suspected. The original significance of the infrared spectrum, or simply 'the infrared' as it is often called, as a form of heat radiation is perhaps less obvious today than it was at the time of its discovery by Herschel in 1800.

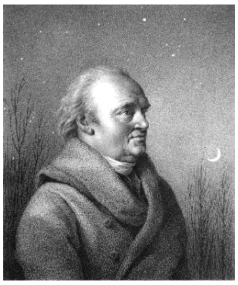


Figure 21.1 Sir William Herschel (1738–1822)

The discovery was made accidentally during the search for a new optical material. Sir William Herschel – Royal Astronomer to King George III of England, and already famous for his discovery of the planet Uranus – was searching for an optical filter material to reduce the brightness of the sun's image in telescopes during solar observations. While testing different samples of colored glass which gave similar reductions in brightness he was intrigued to find that some of the samples passed very little of the sun's heat, while others passed so much heat that he risked eye damage after only a few seconds' observation.

Herschel was soon convinced of the necessity of setting up a systematic experiment, with the objective of finding a single material that would give the desired reduction in brightness as well as the maximum reduction in heat. He began the experiment by actually repeating Newton's prism experiment, but looking for the heating effect rather than the visual distribution of intensity in the spectrum. He first blackened the bulb of a sensitive mercury-in-glass thermometer with ink, and with this as his radiation detector he proceeded to test the heating effect of the various colors of the spectrum formed on the top of a table by passing sunlight through a glass prism. Other thermometers, placed outside the sun's rays, served as controls.

As the blackened thermometer was moved slowly along the colors of the spectrum, the temperature readings showed a steady increase from the violet end to the red end. This was not entirely unexpected, since the Italian researcher, Landriani, in a similar experiment in 1777 had observed much the same effect. It was Herschel, however, who was the first to recognize that there must be a point where the heating effect reaches a maximum, and that measurements confined to the visible portion of the spectrum failed to locate this point.

Figure 21.2 Marsilio Landriani (1746–1815)

Moving the thermometer into the dark region beyond the red end of the spectrum, Herschel confirmed that the heating continued to increase. The maximum point, when he found it, lay well beyond the red end – in what is known today as the 'infrared wavelengths'.

When Herschel revealed his discovery, he referred to this new portion of the electromagnetic spectrum as the ‘thermometrical spectrum’. The radiation itself he sometimes referred to as ‘dark heat’, or simply ‘the invisible rays’. Ironically, and contrary to popular opinion, it wasn't Herschel who originated the term ‘infrared’. The word only began to appear in print around 75 years later, and it is still unclear who should receive credit as the originator.

Herschel’s use of glass in the prism of his original experiment led to some early controversies with his contemporaries about the actual existence of the infrared wavelengths. Different investigators, in attempting to confirm his work, used various types of glass indiscriminately, having different transparencies in the infrared. Through his later experiments, Herschel was aware of the limited transparency of glass to the newly-discovered thermal radiation, and he was forced to conclude that optics for the infrared would probably be doomed to the use of reflective elements exclusively (i.e. plane and curved mirrors). Fortunately, this proved to be true only until 1830, when the Italian investigator, Melloni, made his great discovery that naturally occurring rock salt (NaCl) – which was available in large enough natural crystals to be made into lenses and prisms – is remarkably transparent to the infrared. The result was that rock salt became the principal infrared optical material, and remained so for the next hundred years, until the art of synthetic crystal growing was mastered in the 1930’s.

Figure 21.3 Macedonio Melloni (1798–1854)

Thermometers, as radiation detectors, remained unchallenged until 1829, the year Nobili invented the thermocouple. (Herschel’s own thermometer could be read to 0.2 °C (0.036 °F), and later models were able to be read to 0.05 °C (0.09 °F)). Then a breakthrough occurred; Melloni connected a number of thermocouples in series to form the first thermopile. The new device was at least 40 times as sensitive as the best thermometer of the day for detecting heat radiation – capable of detecting the heat from a person standing three meters away.

The first so-called ‘heat-picture’ became possible in 1840, the result of work by Sir John Herschel, son of the discoverer of the infrared and a famous astronomer in his own right. Based upon the differential evaporation of a thin film of oil when exposed to a heat pattern focused upon it, the thermal image could be seen by reflected light where the interference effects of the oil film made the image visible to the eye. Sir John also managed to obtain a primitive record of the thermal image on paper, which he called a ‘thermograph’.

Figure 21.4 Samuel P. Langley (1834–1906)

The improvement of infrared-detector sensitivity progressed slowly. Another major breakthrough, made by Langley in 1880, was the invention of the bolometer. This consisted of a thin blackened strip of platinum connected in one arm of a Wheatstone bridge circuit upon which the infrared radiation was focused and to which a sensitive galvanometer responded. This instrument is said to have been able to detect the heat from a cow at a distance of 400 meters.

An English scientist, Sir James Dewar, first introduced the use of liquefied gases as cooling agents (such as liquid nitrogen with a temperature of -196 °C (-320.8 °F)) in low temperature research. In 1892 he invented a unique vacuum insulating container in which it is possible to store liquefied gases for entire days. The common ‘thermos bottle’, used for storing hot and cold drinks, is based upon his invention.

Between the years 1900 and 1920, the inventors of the world ‘discovered’ the infrared. Many patents were issued for devices to detect personnel, artillery, aircraft, ships – and even icebergs. The first operating systems, in the modern sense, began to be developed during the 1914–18 war, when both sides had research programs devoted to the military exploitation of the infrared. These programs included experimental systems for enemy intrusion/detection, remote temperature sensing, secure communications, and ‘flying torpedo’ guidance. An infrared search system tested during this period was able to detect an approaching airplane at a distance of 1.5 km (0.94 miles), or a person more than 300 meters (984 ft.) away.

The most sensitive systems up to this time were all based upon variations of the bolometer idea, but the period between the two wars saw the development of two revolutionary new infrared detectors: the image converter and the photon detector. At first, the image converter received the greatest attention by the military, because it enabled an observer for the first time in history to literally ‘see in the dark’. However, the sensitivity of the image converter was limited to the near infrared wavelengths, and the most interesting military targets (i.e. enemy soldiers) had to be illuminated by infrared search beams. Since this involved the risk of giving away the observer’s position to a similarly-equipped enemy observer, it is understandable that military interest in the image converter eventually faded.

The tactical military disadvantages of so-called 'active’ (i.e. search beam-equipped) thermal imaging systems provided impetus following the 1939–45 war for extensive secret military infrared-research programs into the possibilities of developing ‘passive’ (no search beam) systems around the extremely sensitive photon detector. During this period, military secrecy regulations completely prevented disclosure of the status of infrared-imaging technology. This secrecy only began to be lifted in the middle of the 1950’s, and from that time adequate thermal-imaging devices finally began to be available to civilian science and industry.

22 Theory of thermography

22.1 Introduction

The subjects of infrared radiation and the related technique of thermography are still new to many who will use an infrared camera. In this section the theory behind thermography will be given.

22.2 The electromagnetic spectrum

The electromagnetic spectrum is divided arbitrarily into a number of wavelength regions, called *bands*, distinguished by the methods used to produce and detect the radiation. There is no fundamental difference between radiation in the different bands of the electromagnetic spectrum. They are all governed by the same laws and the only differences are those due to differences in wavelength.

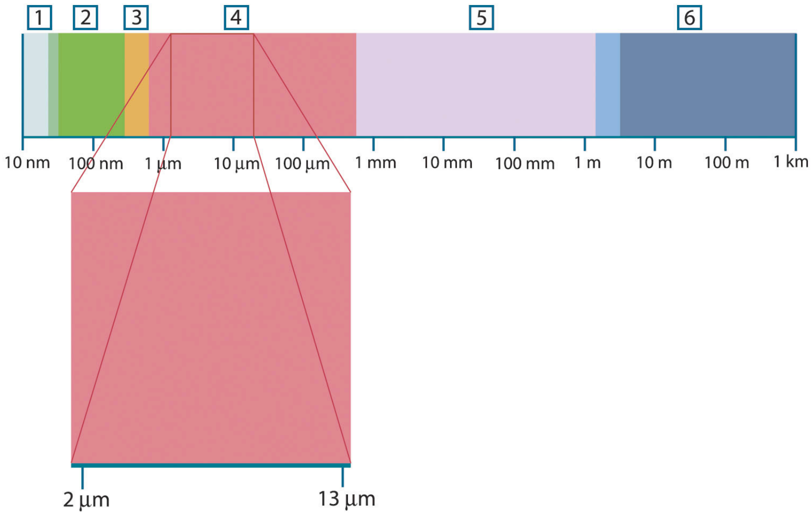


Figure 22.1 The electromagnetic spectrum. 1: X-ray; 2: UV; 3: Visible; 4: IR; 5: Microwaves; 6: Radiowaves.

Thermography makes use of the infrared spectral band. At the short-wavelength end the boundary lies at the limit of visual perception, in the deep red. At the long-wavelength end it merges with the microwave radio wavelengths, in the millimeter range.

The infrared band is often further subdivided into four smaller bands, the boundaries of which are also arbitrarily chosen. They include: the *near infrared* (0.75–3 µm), the *middle infrared* (3–6 µm), the *far infrared* (6–15 µm) and the *extreme infrared* (15–100 µm). Although the wavelengths are given in µm (micrometers), other units are often still used to measure wavelength in this spectral region, *e.g.* nanometer (nm) and Ångström (Å).

The relationships between the different wavelength measurements is:

$$10\ 000\ \text{Å} = 1\ 000\ \text{nm} = 1\ \mu = 1\ \mu\text{m}$$

22.3 Blackbody radiation

A blackbody is defined as an object which absorbs all radiation that impinges on it at any wavelength. The apparent misnomer *black* relating to an object emitting radiation is explained by Kirchhoff's Law (after *Gustav Robert Kirchhoff*, 1824–1887), which states that a body capable of absorbing all radiation at any wavelength is equally capable in the emission of radiation.

Figure 22.2 Gustav Robert Kirchhoff (1824–1887)

The construction of a blackbody source is, in principle, very simple. The radiation characteristics of an aperture in an isotherm cavity made of an opaque absorbing material represents almost exactly the properties of a blackbody. A practical application of the principle to the construction of a perfect absorber of radiation consists of a box that is light tight except for an aperture in one of the sides. Any radiation which then enters the hole is scattered and absorbed by repeated reflections so only an infinitesimal fraction can possibly escape. The blackness which is obtained at the aperture is nearly equal to a blackbody and almost perfect for all wavelengths.

By providing such an isothermal cavity with a suitable heater it becomes what is termed a *cavity radiator*. An isothermal cavity heated to a uniform temperature generates blackbody radiation, the characteristics of which are determined solely by the temperature of the cavity. Such cavity radiators are commonly used as sources of radiation in temperature reference standards in the laboratory for calibrating thermographic instruments, such as a FLIR Systems camera for example.

If the temperature of blackbody radiation increases to more than 525°C (977°F), the source begins to be visible so that it appears to the eye no longer black. This is the incipient red heat temperature of the radiator, which then becomes orange or yellow as the temperature increases further. In fact, the definition of the so-called *color temperature* of an object is the temperature to which a blackbody would have to be heated to have the same appearance.

Now consider three expressions that describe the radiation emitted from a blackbody.

22.3.1 Planck's law

Figure 22.3 Max Planck (1858–1947)

Max Planck (1858–1947) was able to describe the spectral distribution of the radiation from a blackbody by means of the following formula:

$$W_{\lambda b} = \frac{2\pi hc^2}{\lambda^5 \left(e^{hc/\lambda kT} - 1\right)} \times 10^{-6} [Watt\,/\,m^2, \mu m]$$

where:

$W_{\lambda b}$	Blackbody spectral radiant emittance at wavelength λ.
c	Velocity of light = 3×10^8 m/s
h	Planck's constant = 6.6×10^{-34} Joule sec.
k	Boltzmann's constant = 1.4×10^{-23} Joule/K.
T	Absolute temperature (K) of a blackbody.
λ	Wavelength (μm).

Note The factor 10^{-6} is used since spectral emittance in the curves is expressed in Watt/m^2, μm.

Planck's formula, when plotted graphically for various temperatures, produces a family of curves. Following any particular Planck curve, the spectral emittance is zero at λ = 0, then increases rapidly to a maximum at a wavelength λ_{max} and after passing it approaches zero again at very long wavelengths. The higher the temperature, the shorter the wavelength at which maximum occurs.

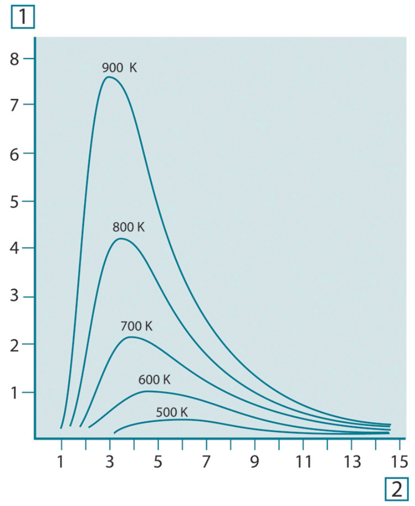


Figure 22.4 Blackbody spectral radiant emittance according to Planck's law, plotted for various absolute temperatures. 1: Spectral radiant emittance (W/cm^2 × 10^3(μm)); 2: Wavelength (μm)

22.3.2 Wien's displacement law

By differentiating Planck's formula with respect to λ, and finding the maximum, we have:

$$\lambda_{\max} = \frac{2898}{T}[\mu m]$$

This is Wien's formula (after *Wilhelm Wien*, 1864–1928), which expresses mathematically the common observation that colors vary from red to orange or yellow as the temperature of a thermal radiator increases. The wavelength of the color is the same as the wavelength calculated for λ_{max}. A good approximation of the value of λ_{max} for a given blackbody temperature is obtained by applying the rule-of-thumb 3 000/T μm. Thus, a very hot star such as Sirius (11 000 K), emitting bluish-white light, radiates with the peak of spectral radiant emittance occurring within the invisible ultraviolet spectrum, at wavelength 0.27 μm.

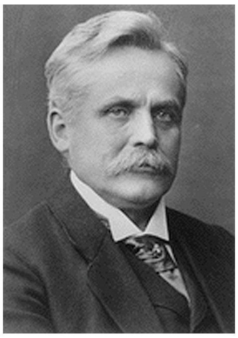


Figure 22.5 Wilhelm Wien (1864–1928)

The sun (approx. 6 000 K) emits yellow light, peaking at about 0.5 µm in the middle of the visible light spectrum.

At room temperature (300 K) the peak of radiant emittance lies at 9.7 µm, in the far infrared, while at the temperature of liquid nitrogen (77 K) the maximum of the almost insignificant amount of radiant emittance occurs at 38 µm, in the extreme infrared wavelengths.

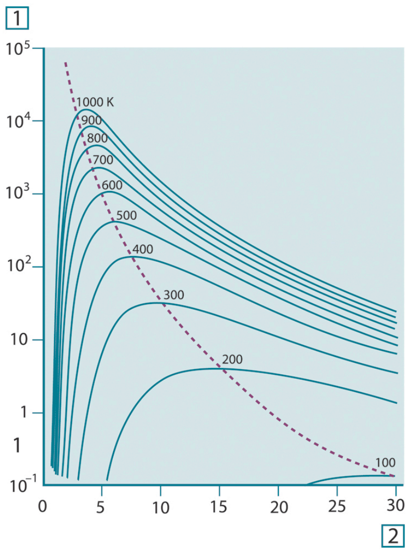


Figure 22.6 Planckian curves plotted on semi-log scales from 100 K to 1000 K. The dotted line represents the locus of maximum radiant emittance at each temperature as described by Wien's displacement law. 1: Spectral radiant emittance (W/cm² (µm)); 2: Wavelength (µm).

22.3.3 Stefan-Boltzmann's law

By integrating Planck's formula from λ = 0 to λ = ∞, we obtain the total radiant emittance (W_b) of a blackbody:

$$W_b = \sigma T^4 \ [\mathrm{Watt/m^2}]$$

This is the Stefan-Boltzmann formula (after *Josef Stefan*, 1835–1893, and *Ludwig Boltzmann*, 1844–1906), which states that the total emissive power of a blackbody is proportional to the fourth power of its absolute temperature. Graphically, W_b represents the area below the Planck curve for a particular temperature. It can be shown that the radiant emittance in the interval λ = 0 to λ_{max} is only 25% of the total, which represents about the amount of the sun's radiation which lies inside the visible light spectrum.

Figure 22.7 Josef Stefan (1835–1893), and Ludwig Boltzmann (1844–1906)

Using the Stefan-Boltzmann formula to calculate the power radiated by the human body, at a temperature of 300 K and an external surface area of approx. 2 m^2, we obtain 1 kW. This power loss could not be sustained if it were not for the compensating absorption of radiation from surrounding surfaces, at room temperatures which do not vary too drastically from the temperature of the body – or, of course, the addition of clothing.

22.3.4 Non-blackbody emitters

So far, only blackbody radiators and blackbody radiation have been discussed. However, real objects almost never comply with these laws over an extended wavelength region – although they may approach the blackbody behavior in certain spectral intervals. For example, a certain type of white paint may appear perfectly *white* in the visible light spectrum, but becomes distinctly *gray* at about 2 μm, and beyond 3 μm it is almost *black*.

There are three processes which can occur that prevent a real object from acting like a blackbody: a fraction of the incident radiation α may be absorbed, a fraction ρ may be reflected, and a fraction τ may be transmitted. Since all of these factors are more or less wavelength dependent, the subscript λ is used to imply the spectral dependence of their definitions. Thus:

- The spectral absorptance α_λ= the ratio of the spectral radiant power absorbed by an object to that incident upon it.
- The spectral reflectance ρ_λ = the ratio of the spectral radiant power reflected by an object to that incident upon it.
- The spectral transmittance τ_λ = the ratio of the spectral radiant power transmitted through an object to that incident upon it.

The sum of these three factors must always add up to the whole at any wavelength, so we have the relation:

$$\alpha_\lambda + \rho_\lambda + \tau_\lambda = 1$$

For opaque materials $\tau_\lambda = 0$ and the relation simplifies to:

$$\varepsilon_\lambda + \rho_\lambda = 1$$

Another factor, called the emissivity, is required to describe the fraction ε of the radiant emittance of a blackbody produced by an object at a specific temperature. Thus, we have the definition:

The spectral emissivity ε_λ= the ratio of the spectral radiant power from an object to that from a blackbody at the same temperature and wavelength.

Expressed mathematically, this can be written as the ratio of the spectral emittance of the object to that of a blackbody as follows:

$$\varepsilon_\lambda = \frac{W_{\lambda o}}{W_{\lambda b}}$$

Generally speaking, there are three types of radiation source, distinguished by the ways in which the spectral emittance of each varies with wavelength.

- A blackbody, for which $\varepsilon_\lambda = \varepsilon = 1$
- A graybody, for which $\varepsilon_\lambda = \varepsilon$ = constant less than 1

- A selective radiator, for which ε varies with wavelength

According to Kirchhoff's law, for any material the spectral emissivity and spectral absorptance of a body are equal at any specified temperature and wavelength. That is:

$$\varepsilon_\lambda = \alpha_\lambda$$

From this we obtain, for an opaque material (since $\alpha_\lambda + \rho_\lambda = 1$):

$$\varepsilon_\lambda + \rho_\lambda = 1$$

For highly polished materials ε_λ approaches zero, so that for a perfectly reflecting material (*i.e.* a perfect mirror) we have:

$$\rho_\lambda = 1$$

For a graybody radiator, the Stefan-Boltzmann formula becomes:

$$W = \varepsilon \sigma T^4 \ [\mathrm{Watt/m^2}]$$

This states that the total emissive power of a graybody is the same as a blackbody at the same temperature reduced in proportion to the value of ε from the graybody.

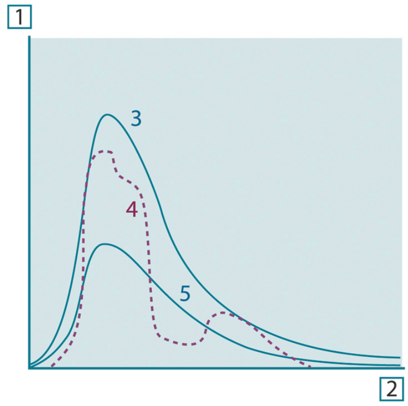


Figure 22.8 Spectral radiant emittance of three types of radiators. 1: Spectral radiant emittance; 2: Wavelength; 3: Blackbody; 4: Selective radiator; 5: Graybody.

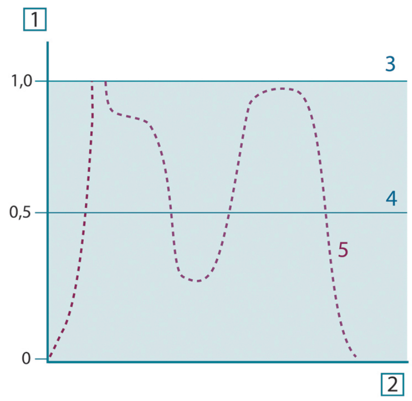


Figure 22.9 Spectral emissivity of three types of radiators. 1: Spectral emissivity; 2: Wavelength; 3: Blackbody; 4: Graybody; 5: Selective radiator.

22.4 Infrared semi-transparent materials

Consider now a non-metallic, semi-transparent body – let us say, in the form of a thick flat plate of plastic material. When the plate is heated, radiation generated within its volume must work its way toward the surfaces through the material in which it is partially absorbed. Moreover, when it arrives at the surface, some of it is reflected back into the interior. The back-reflected radiation is again partially absorbed, but some of it arrives at the other surface, through which most of it escapes; part of it is reflected back again. Although the progressive reflections become weaker and weaker they must all be added up when the total emittance of the plate is sought. When the resulting geometrical series is summed, the effective emissivity of a semi-transparent plate is obtained as:

$$\varepsilon_\lambda = \frac{(1-\rho_\lambda)(1-\tau_\lambda)}{1-\rho_\lambda\tau_\lambda}$$

When the plate becomes opaque this formula is reduced to the single formula:

$$\varepsilon_\lambda = 1-\rho_\lambda$$

This last relation is a particularly convenient one, because it is often easier to measure reflectance than to measure emissivity directly.

23 The measurement formula

As already mentioned, when viewing an object, the camera receives radiation not only from the object itself. It also collects radiation from the surroundings reflected via the object surface. Both these radiation contributions become attenuated to some extent by the atmosphere in the measurement path. To this comes a third radiation contribution from the atmosphere itself.

This description of the measurement situation, as illustrated in the figure below, is so far a fairly true description of the real conditions. What has been neglected could for instance be sun light scattering in the atmosphere or stray radiation from intense radiation sources outside the field of view. Such disturbances are difficult to quantify, however, in most cases they are fortunately small enough to be neglected. In case they are not negligible, the measurement configuration is likely to be such that the risk for disturbance is obvious, at least to a trained operator. It is then his responsibility to modify the measurement situation to avoid the disturbance e.g. by changing the viewing direction, shielding off intense radiation sources etc.

Accepting the description above, we can use the figure below to derive a formula for the calculation of the object temperature from the calibrated camera output.

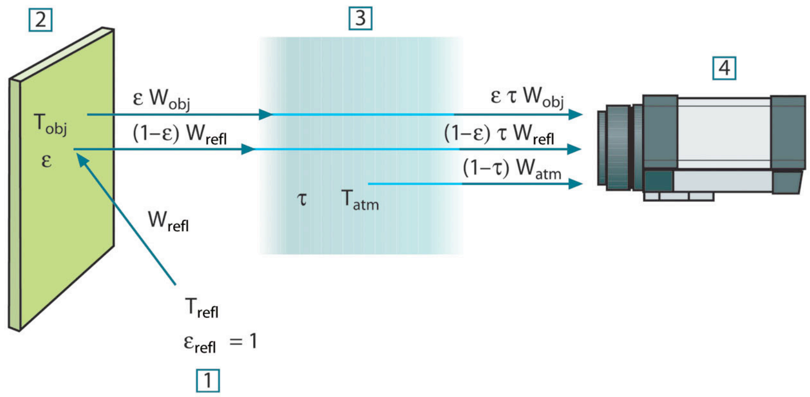


Figure 23.1 A schematic representation of the general thermographic measurement situation.1: Surroundings; 2: Object; 3: Atmosphere; 4: Camera

Assume that the received radiation power W from a blackbody source of temperature T_{source} on short distance generates a camera output signal U_{source} that is proportional to the power input (power linear camera). We can then write (Equation 1):

$$U_{source} = CW(T_{source})$$

or, with simplified notation:

$$U_{source} = CW_{source}$$

where C is a constant.

Should the source be a graybody with emittance ε, the received radiation would consequently be εW_{source}.

We are now ready to write the three collected radiation power terms:

1. *Emission from the object* = $\varepsilon\tau W_{obj}$, where ε is the emittance of the object and τ is the transmittance of the atmosphere. The object temperature is T_{obj}.

2. *Reflected emission from ambient sources* = $(1 - \varepsilon)\tau W_{refl}$, where $(1 - \varepsilon)$ is the reflectance of the object. The ambient sources have the temperature T_{refl}.
   It has here been assumed that the temperature T_{refl} is the same for all emitting surfaces within the halfsphere seen from a point on the object surface. This is of course sometimes a simplification of the true situation. It is, however, a necessary simplification in order to derive a workable formula, and T_{refl} can – at least theoretically – be given a value that represents an efficient temperature of a complex surrounding.

   Note also that we have assumed that the emittance for the surroundings = 1. This is correct in accordance with Kirchhoff's law: All radiation impinging on the surrounding surfaces will eventually be absorbed by the same surfaces. Thus the emittance = 1. (Note though that the latest discussion requires the complete sphere around the object to be considered.)
3. *Emission from the atmosphere* = $(1 - \tau)\tau W_{atm}$, where $(1 - \tau)$ is the emittance of the atmosphere. The temperature of the atmosphere is T_{atm}.

The total received radiation power can now be written (Equation 2):

$$W_{tot} = \varepsilon\tau W_{obj} + (1-\varepsilon)\tau W_{refl} + (1-\tau)W_{atm}$$

We multiply each term by the constant C of Equation 1 and replace the CW products by the corresponding U according to the same equation, and get (Equation 3):

$$U_{tot} = \varepsilon\tau U_{obj} + (1-\varepsilon)\tau U_{refl} + (1-\tau)U_{atm}$$

Solve Equation 3 for U_{obj} (Equation 4):

$$U_{obj} = \frac{1}{\varepsilon\tau}U_{tot} - \frac{1-\varepsilon}{\varepsilon}U_{refl} - \frac{1-\tau}{\varepsilon\tau}U_{atm}$$

This is the general measurement formula used in all the FLIR Systems thermographic equipment. The voltages of the formula are:

Table 23.1 Voltages

U_{obj}	Calculated camera output voltage for a blackbody of temperature T_{obj} i.e. a voltage that can be directly converted into true requested object temperature.
U_{tot}	Measured camera output voltage for the actual case.
U_{refl}	Theoretical camera output voltage for a blackbody of temperature T_{refl} according to the calibration.
U_{atm}	Theoretical camera output voltage for a blackbody of temperature T_{atm} according to the calibration.

The operator has to supply a number of parameter values for the calculation:

- the object emittance ε,
- the relative humidity,
- T_{atm}
- object distance (D_{obj})
- the (effective) temperature of the object surroundings, or the reflected ambient temperature T_{refl}, and
- the temperature of the atmosphere T_{atm}

This task could sometimes be a heavy burden for the operator since there are normally no easy ways to find accurate values of emittance and atmospheric transmittance for the actual case. The two temperatures are normally less of a problem provided the surroundings do not contain large and intense radiation sources.

A natural question in this connection is: How important is it to know the right values of these parameters? It could though be of interest to get a feeling for this problem already here by looking into some different measurement cases and compare the relative magnitudes of the three radiation terms. This will give indications about when it is important to use correct values of which parameters.

The figures below illustrates the relative magnitudes of the three radiation contributions for three different object temperatures, two emittances, and two spectral ranges: SW and LW. Remaining parameters have the following fixed values:

- τ = 0.88
- T_{refl} = +20°C (+68°F)
- T_{atm} = +20°C (+68°F)

It is obvious that measurement of low object temperatures are more critical than measuring high temperatures since the 'disturbing' radiation sources are relatively much stronger in the first case. Should also the object emittance be low, the situation would be still more difficult.

We have finally to answer a question about the importance of being allowed to use the calibration curve above the highest calibration point, what we call extrapolation. Imagine that we in a certain case measure U_{tot} = 4.5 volts. The highest calibration point for the camera was in the order of 4.1 volts, a value unknown to the operator. Thus, even if the object happened to be a blackbody, i.e. $U_{obj} = U_{tot}$, we are actually performing extrapolation of the calibration curve when converting 4.5 volts into temperature.

Let us now assume that the object is not black, it has an emittance of 0.75, and the transmittance is 0.92. We also assume that the two second terms of Equation 4 amount to 0.5 volts together. Computation of U_{obj} by means of Equation 4 then results in U_{obj} = 4.5 / 0.75 / 0.92 – 0.5 = 6.0. This is a rather extreme extrapolation, particularly when considering that the video amplifier might limit the output to 5 volts! Note, though, that the application of the calibration curve is a theoretical procedure where no electronic or other limitations exist. We trust that if there had been no signal limitations in the camera, and if it had been calibrated far beyond 5 volts, the resulting curve would have been very much the same as our real curve extrapolated beyond 4.1 volts, provided the calibration algorithm is based on radiation physics, like the FLIR Systems algorithm. Of course there must be a limit to such extrapolations.

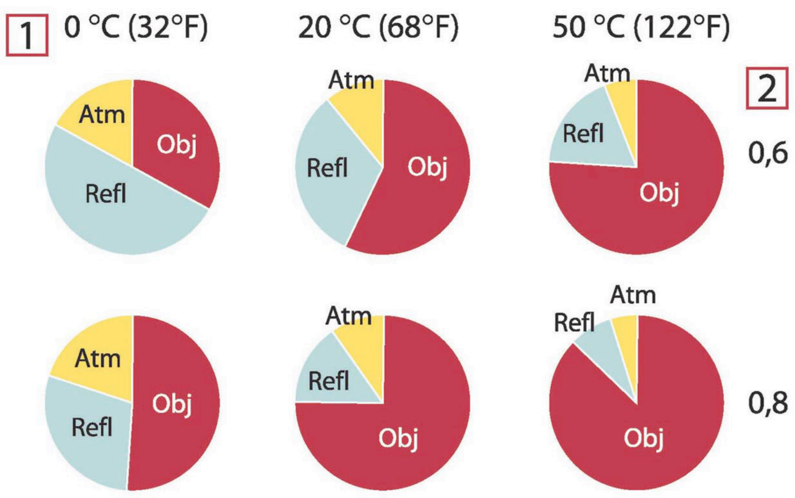


Figure 23.2 Relative magnitudes of radiation sources under varying measurement conditions (SW camera). 1: Object temperature; 2: Emittance; Obj: Object radiation; Refl: Reflected radiation; Atm: atmosphere radiation. Fixed parameters: τ = 0.88; T_{refl} = 20°C (+68°F); T_{atm} = 20°C (+68°F).

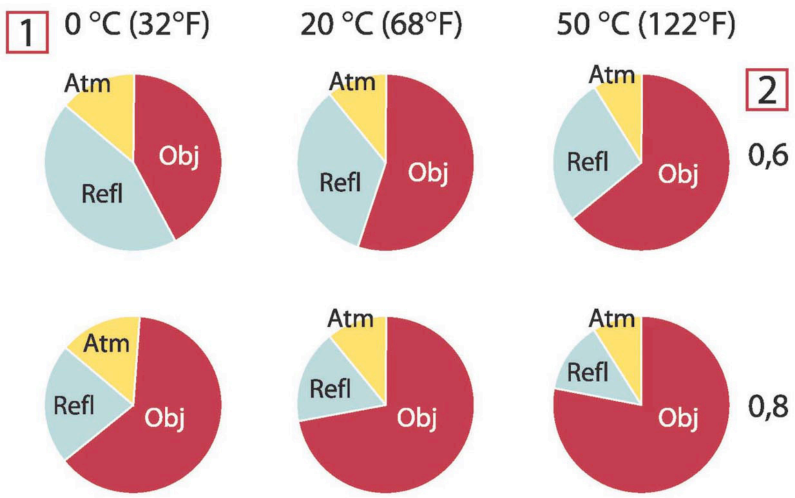


Figure 23.3 Relative magnitudes of radiation sources under varying measurement conditions (LW camera). 1: Object temperature; 2: Emittance; Obj: Object radiation; Refl: Reflected radiation; Atm: atmosphere radiation. Fixed parameters: τ = 0.88; T_{refl} = 20°C (+68°F); T_{atm} = 20°C (+68°F).

A note on the technical production of this publication

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